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PHOTOGRAPHY AND THE FIGURE OF THE SUN.

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FOR POPULAR ASTRONOMY.

Because photography as applied to the finding of astronomical data is a new method of work astronomers of large experience have been somewhat afraid of it as a method of precision in comparison with some of the older and well settled ways of measurement.

This matter has been recently brought to our attention in a well written article by Charles Lane Poor in the September number of the *Astrophysical Journal*, page 103, in which he sets forth the value of photography as a means of measurement to determine the figure of the Sun. It is well known to the practical astronomer that the heliometer as an instrument, in the hands of an observer who knows how to use it for all it is worth, is the most refined and accurate measuring machine now known to astronomy.

Now, when Professor Poor brings forward the photographic method and compares its measurements with those of the heliometer, he challenges the best work in celestial measurement for more than sixty years and since the time of the famous Bessel. Naturally the readers of this important paper will look at its methods and its conclusions with close attention.

In the first part of the paper, we have the consideration of 139 Rutherfurd solar photographs taken during the years 1860-74. Such of these as could be measured, were selected, compared and combined in tabular way and weighted. From the method of discussion it appears that as Professor Poor says the different plates for each year give quite consistent results, but the mean results for the different years differ radically. The plates for 1871 show the equatorial radius to exceed the polar radius by some 0.″3, while the plates 1870 and 1872, on the other hand show the polar radius to be the greater by some 0.″2. Forming the mean by weights of the results obtained from the plates in the

different years, we see that the yearly means are as follows:

1870 Sept. 22 + 0.″50 ± 0.″10
1871 July 19 − 0. 32 ± 0. 16
1872 July 2 + 0. 22 ± 0. 09

We have put the latter part of the preceding paragraph in Professor Poor's own language that we might state exactly his meaning; for, if true, these are remarkable results. They come from the earliest work done in solar photography on which can be based a claim of definitive measurement; for from 1860 to 1874, solar photography did not claim very serious attention anywhere except in a very few instances, as a means of securing valuable astronomical data.

If these and other similar measures, when thoroughly discussed, do really show a change in the relative sizes of the polar and equatorial diameters of the Sun, that fact will place solar photography, as a means of refined measurement clearly in the lead of all others for that purpose.

We know that the work of the heliometer does give some indications of the correctness of the conclusions of this paper, and it is possible that the careful discussion of Professor Poor regarding the work of the heliometer in the hands of so skilful an astronomer as Dr. Auwers may be right, although not in agreement with the conclusions of several other able mathematicians and astronomers. The reason why great caution is needed here is the fact that the results obtained depend so largely and so manifestly on the method of grouping the observations. There is the further question about the weights of the observations that have been used. So little is said on this point in Professor Poor's paper that we judge, he was satisfied that no material error could arise from this source to account for the very different conclusions obtained by different astronomers. The way the observations were weighted might be a source of help to independent judgment in regard to the strict or provisional character of the results obtained from these different classes of observations.

When we came to the discussion of the Northfield plates we notice some things that need special attention. It is said, on page 112 of the September number of the *Astrophysical Journal* that "Dr. H. C. Wilson has taken a long series of solar photographs at Northfield, Minn. Only a few of these photographs are available for measurement; most of the plates lack satisfactory orientation and in many the edge of the image is blurred owing to a defective shutter."

This is a very unfortunate statement in regard to the character of the solar photographs by Dr. Wilson. In justice to him and

to give a correct impression of the real worth of these solar photographs, we wish to say that when the data for Professor Poor's paper was being collected a few of Dr. Wilson's solar photographs were asked for; five were sent which if memory serves me rightly was more than was asked. This we suppose to be the reason that "only a few of these photographs were available for measurement." A large number of good negatives could have been furnished if they had been asked for. Possibly Professor Poor's result would have been different in regard to the Northfield plates if he had measured 179 instead of 5, the whole furnished from Northfield. When the author uses 179 of the Rutherfurd plates in the general discussion and only five of the Northfield plates, it would seem fairer not to draw lines of character of value quite so sharply.

But the statement that most of the Northfield plates lack satisfactory orientation, and in many the image is blurred owing to a defective shutter is still more surprising. If we are competent judges of plates taken at Northfield we say most of them are very good for almost all kinds of measurement now in use anywhere. All are oriented sufficiently for determining the location of ordinary sun-spots, and, as far as we can see for the uses which Professor Poor made of them. But if these plates were to be used for the exact study of the latitudes of very perfect sun-spots, their orientation would be insufficient, it being determined by the drift of spots along the orienting thread.

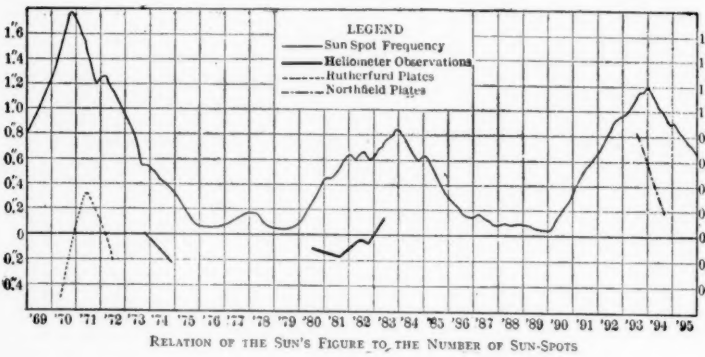
In regard to the blurring on the edges of the photographic image, it should be said that the north and south edges of the images do show such effects slightly. This is owing partly to the impulse given to the telescope by the release of the shutter in a quick exposure and, partly probably, to the effect of diffraction of the jaws of the shutter when it is made too narrow. Now this blurring effect on the limb of the image of the Sun is not visible to the naked eye at all, and we cannot see how it would be a serious defect for the measures that were used in the study presented in Professor Poor's paper. We very much wish he had said something on this point in regard to the Rutherfurd solar photographs.

We have spoken thus particularly of this interesting paper because we think very highly of it and we hope to see this work prosecuted further, Professor Poor working in the right direction.

We give the conclusion of his paper in his own words with the illustration that shows much to the eye at a glance. We have reduced his cut to the width of our page.

RELATION OF THE SUN'S FIGURE TO THE NUMBER OF SUN-SPOTS.

A sun-spot maximum occurred in the latter part of 1870, and from this time until 1876 there was a steady dimunition in the number of spots. In 1870 and 1871, just previous to the maximum, the Rutherfurd plates show that the equatorial diameter was increasing, but during the period 1871 to 1876 the Rutherford photographs and the heliometer measures both show that the equatorial diameter was shrinking relatively to the polar diameter. The period from 1880 to 1883 was a period when the number of sun-spots was increasing, the sun-spot maximum occuring in the latter part of 1883. During this period the heliometer measures indicate that the equatorial diameter was increas-



RELATION OF THE SUN'S FIGURE TO THE NUMBER OF SUN-SPOTS

ing relatively to the polar diameter. But the 1883 sun-spot maximum was hardly half as high as the maximum in 1870, and we should expect, therefore, to find the changes in the Sun's diameter less marked in the later period than in that of 1870. This is exactly what the determinations show. A third sunspot maximum occurred in the latter part of 1893, and during 1894 the number of spots rapidly decreased. The Northfield plates show that during this period the equatorial radius was decreasing relatively to the polar radius.

This relation between the frequency of sun-spots and the figure of the Sun is shown in the accompanying diagram. The curve of sun-spot frequency is taken from Miss Clerke's *Problems in Astrophysics*. The dotted curve represents the relation between the equatorial and polar radii of the Sun, as deduced from the Rutherfurd plates; the full heavy curves, the changes as exhibited by the heliometer measures, and the broken line, the changes as

indicated by the Northfield plates. These curves are plotted from the weighted means of the observations, as given in the above tables, but with the signs reversed, so that the portions of the curves above the zero line represent those observations which show the equatorial diameter to exceed the polar. The slopes of the observational curves are nearly parallel to the corresponding portions of the sun-spot curve, and the general character of these curves shows a striking resemblance to the curve of sun-spot frequency.

The present investigation would seem to show, therefore, that the ratio between the polar and equatorial radii of the Sun is variable, and that the period of this variability is the same as the sun-spot period. The Sun appears to be a vibrating body whose equatorial diameter, on the average, slightly exceeds the polar diameter. At times, however, the polar diameter becomes equal to and even greater than the equatorial—the Sun thus passing from an oblate to a prolate spheroid.

In this variable figure of the Sun may lie the explanation of the anomalies in the motions of *Mercury*, *Venus*, and *Mars*.

THE CANALS OF MARS—PHOTOGRAPHED.

PERCIVAL LOWELL.

To photograph the canals of *Mars* has long been a purpose at this observatory. The first attempt was made in 1901 by Mr. Douglass who, with a Wallace screen, secured a good print of the Mare Acidalium. Encouraging as the result was no canal could then with certainty be detected on the negative. At the next opposition attempts nearly as inconclusive were made by Mr. Lampland. No canals could be sufficiently well recognized on the plates, though some can be dimly detected.

Two difficulties stood in the way: the one, the varying air-waves which now favor, now prevent, the definition of such fine detail as that of the canals; the other, the insufficient speed of photographic plates. In the registering of such detail the eye has a great advantage over the camera; for it can perceive much more sensitively than the plate and furthermore retains an image only for the twentieth part of a second. It can thus record a moment of apparition; the camera cannot, but must take the good with the bad and yield only a blurred composite picture of both.

The writer therefore determined to have made a camera on the

pattern of a bioscopic film in which, behind a Wallace screen, many successive pictures might be taken in the hopes of securing among them some showing the canals. This idea, with Mr. Lampland's valuable suggestions on the subject, he communicated to the Alvan Clark and Sons Corporation. Mr. Lundin made what best he could devise but the result left much to be desired, chiefly the automatic motion, the camera having to be worked by hand. In spite of, rather than in consequence of, this camera the present photographs were secured by Mr. Lampland to whose study, ability and skill the result is due.

A furthering circumstance was a new driving clock recommended to the writer by Mr. W. A. Cogshall, formerly of this observatory, made by Gaertner of Chicago, which has proved excellently smooth in its running.

But the essential factor that brought success was the one which has been found here so vital to visual observation—the diaphragming down of the objective to suit the atmospheric currents at the time of the observation. Not only did a diaphragm prove better than the full objective but the increased gain in definition was so great as to much more than offset all the bad effects of prolonged exposure.

The importance of the artifice in visual observation and the reasons for it were given in a paper presented by the writer this spring to the Societe Astronomique de France as well as in another sent later to Professor H. H. Turner to be read before the Royal Astronomical Society. As these papers were based on visual observation only it is a fact of some interest that photography should thus corroborate visual observation in means as well as end. Photographically Professor Wadsworth had acutely come to the necessity of diaphragming at about the time when researches into the character of the atmospheric waves were made here by Mr. Douglass, and he communicated to the '*Observatory*' some very valuable papers advocating the use of small apertures in planetary photography because of the greater disturbances in a large glass. He did not, however, give any explanation of the action of disturbance by the air waves and no photographs were to my knowledge made.

Out of many plates secured one is here represented—the one dealing with the region of the Syrtis Major, photographed on May 11. Side by side with it is placed a photograph of a drawing by the writer made shortly before the camera was put on. This serves the double purpose of showing the confirmation by the photograph of the objectivity of the visual observation and at

the same time of serving as a chart to it.

If the reader will compare the several photographic images of the planet with the map of *Mars* he should be able to recognize on them the following markings:

Regions—Syrtis Major, Mare Erythraeum, Mare Icarium, Hellas, North Polar Cap.

Canals—Nilosyrtis, Pyramus, Casius, Protonilus, Pierius, Vexillum, Astaboras S, Thoth.

Oasis—Lucus Ismenius.

The dark triangle with its apex pointing downward is the Syrtis Major: the dark area at the top, that is to the south of it, is the Mare Erythraeum. Leading off from the Mare Erythraeum to the right shows the narrow dark stretch of the Mare Icarium separating Aeria on the north from Deucalionis regio on the south. The bent line from the bottom of the Syrtis turning sharply to the right as it goes is the Nilosyrtis which continuing westward across the print becomes the Protonilus. Making the rest of a rhomboid with the Nilosyrtis can be descried two short lines, one issuing from near the bottom of the Syrtis on the right, the other rising from the Peboas Lucus at the end of the Nilosyrtis to join it nearly. These are the Astaboras and the Vexillum respectively. Parallel with the second link of the Nilosyrtis and below it shows a long dark line. This is the Casius. From its left hand extremity can just be made out a filament which curves round to the right to enter the Syrtis two-thirds way up on its eastern side. This is the Thoth. From the other end of the Casius proceeds the Pierius.

The plate is from an enlargement of one of the original negatives on a scale of 1.8 times. It seems, on the whole, better adapted to general exposition than prints directly made from the originals because of its greater size. Nevertheless it must be remembered that it is necessarily three removes off from the source since an enlarged positive has first to be made from the original then an enlarged negative from that and finally the print from this last.

Inasmuch as such fine detail as the canals, owing to the air-waves, play bo-peep with either observer or camera, it is not to be expected that the more delicate of them should appear in every print. Yet they turn out to come nearer doing so than could have been anticipated. And this because the exposures could not be made instantaneous but with an aperture of 12 inches were given on the average eight seconds each.

On other plates taken other canals can be made out, notably

those bounding Elysium, together with the Helicon, Erebus and the Hades.

The negatives thoroughly confirm the eye in showing not only the existence of the canals but the fact that they are continuous lines and not a synthesis of other markings. Beyond a certain magnification, if a magnifier be used to examine them, the grain of the plate will show. This must not be taken for discontinuity in the image.

Two points are worthy of notice:

1. The corroboration of the fact of the canals by the photographs.
2. The corroboration of the methods found most efficient to their detection visually.

The following on *Photographing the Canals of Mars* is by C. O. Lampland.

"The accompanying photographs of *Mars* were made with the 24-inch Clark refractor of 386 inches focal length. The camera used, which was designed and made by A. Clark & Sons Corporation, carries an amplifying (negative) lens. The equivalent focal length of the combination for the photographs shown is 148 feet. The camera carries a plate holder, for 3¼ x 4¼ plates, movable perpendicular to the optical axis, permitting a dozen or more exposures of the planet, for the focal length given, to be made on the same plate.

Mr. Ritchey's method of using a color screen in front of the sensitive surface has been employed. The plate holder has a place for color screen immediately in front of the sensitive plate, but in order to minimize the effect of small specks that might occur in the screen or of particles of dust lodging on it, the screen has been placed a short distance in front of the plate. To obtain the maximum transmission capacity and correct absorption value for the color screens the color curve of the large objective and the sensitive curve of the plate to be used were taken into consideration. Three of these screens were made by Mr. R. J. Wallace of the Yerkes Observatory. The transmission of the screens is excellent, no appreciable dimunition in intensity being shown in tests with the spectroscope. No investigation has been made as to possible distortions, geometrical or otherwise, that such screens may introduce. From Mr. Ritchey's results, based upon examination of stellar images in negatives of considerable dimensions taken with the 40-inch Yerkes refractor, it seems safe to assume that if distortion of any kind is present in images of the size used in this work, it must be very slight.

Cramer's Isochromatic plates were selected as the most efficient

on account of their high degree of sensitiveness to light in the region of the spectrum where the color curve of large objective is the flattest. One of the maxima of the curve of sensitiveness of the plate coincides almost exactly with the vertex of the color curve.

The problem of "following" in the present kind of work is rather a difficult one. To attempt guiding with a small telescope

PHOTOGRAPH OF DRAWING OF MARS
BY PERCIVAL LOWELL
MAY 11^d 18^h 35^m G. M. T.
$\lambda = 284°$

PHOTOGRAPH OF MARS
BY C. O. LAMPLAND
MAY 11^d 19^h 44^m-48^m G. M. T.
$\lambda = 303°$

of short focal length, as a finder, and the ordinary slow motions of a large instrument is, of course, out of the question. To interpose a partially reflecting surface in the cone for obtaining an image to guide by, using a Common plate holder for "following," is also objectionable on account of the loss of light, if an image of sufficient intensity for efficient guiding is to be obtained

and possible distortions it may introduce.

A great deal of attention has been given to the worm gear and driving clock in order to eliminate periodicities and to obtain as smooth and uniform motion as possible, so that for exposure of a few seconds actual following would not be attempted. The driving clock used until recently was of the Bond spring governor type, and it was not found possible to obtain with it the desired uniformity and steadiness in driving. Last autumn a driving clock of the conical pendulum type made by Wm. Gaertner of Chicago, was tried but found too small to carry the large telescope satisfactorily. A large clock of the same kind was ordered, and was put in place during the first days of May. The performance of this clock is very satisfactory. With it the present photographs were obtained.

The best results thus far obtained have been with the large objective diaphragmed down to 9 and 12 inches. The larger apertures, of course, possess an advantage in their greater resolving and contrasting capacity, the shorter exposure time and consequently more perfect "following." For a given sensitive plate, considering the size of the silver grain, the ratio of aperture to focal length should be such as to obtain photographic resolution for detail that the aperture is capable of showing. The troublesome factors of "following" and atmospheric disturbances make such theoretical limit difficult of attainment, especially in exposures of some duration. The advantage of an increase in aperture beyond this size is principally that of a brighter image and shorter exposure time. However, the atmospheric disturbances increase so rapidly with the larger apertures that, except under the most favorable conditions, the advantage seems to be with smaller apertures and longer exposures.

As a preliminary preparation for the present problem considerable work was done on *Jupiter* and *Saturn* during the past two years.

In conclusion I wish to return my thanks to Professor Lowell for his constant encouragement, untiring efforts and valuable advice in furthering this work."

ON MAKING NEGATIVE ENLARGEMENTS.*

Now that the exhibition season has fairly started, and photographers are devoting time and consideration to the production

* *The British Journal of Photography*, No. 2369.

of large prints from their small negatives taken during the summer, the following practical notes, abridged from a series of articles by Walter Zimmerman appearing in "Camera Craft," will be of value to many of our readers. Mr. Zimmerman is one of the leading pictorial workers in America, and his methods may be followed with advantage. He says:—"In pictorial photography, if a small picture be perfect, a large one, properly executed, must be pluperfect. There are many circumstances which might appear to give reason for modifying this statement; that the technical quality of the large picture is rarely equal to that of the small one; and that many defects, trifling in the original, become magnified in the large reproduction. Nevertheless, the statement remains exact, for the perfect technical work must be taken for granted in the making of a perfect rendering, and if there are defects in the original it cannot be a perfect picture. The presentation of the work in large size has the great advantage of enabling the artist to remedy defects better than in the small, and the operation calls for all the artistic as well as technical skill of the photographer. Certain it is that where real merit exists, the attention of the public is given principally to the large work, whether on canvas or on photographic paper.

"The rule which we shall adopt here is to explain the process of making large negatives for exhibition photographs in such a way that there shall be no double printing, on the one hand, and that there need be no modifications by manipulations of prints, on the other. The thing that is desired, of course, with large plates and paper, is to get everything in the negative, so that there need be no masking, shading, or other work upon the print, during or after exposure.

"I will also explain, as fully as possible, a special method of making exhibition negatives by a process which has never before been published, so far as I know, but which, nevertheless, has the advantage of accuracy and extreme simplicity.

There are four ways of making negative enlargements on glass, namely:—1. A contact positive and a negative enlargement from it. 2. A positive partial enlargement, and a secondary negative enlargement. 3. A positive enlargement and a contact negative. 4. A negative made by printing through an enlargement on paper. The third and fourth methods are those which produce the most perfect results, and special attention will be paid to them in this article.

"The most perfect large negatives are those which are made by contact with a positive of the same size, rather than through an

enlarging process to produce the negative itself. The third method mentioned in the list is glass contact from glass, and for perfection of technical results nothing can be equal to it. It is, of course, the most expensive way, as two large plates are required, barring failures.

Place the small negative, glass or film (the latter between two pieces of glass), in the kit or frame for negatives in the enlarging window. The daylight passes through the negative, and the lens projects a magnified image on the sliding board or easel. Cut a piece of heavy white cardboard the exact size of the plate to be used, and obtain the size by an approximate focus. If a selected portion of the negative is to be used, that portion only will, of course, be contained on the image projected on the card. If diffusion is wanted from a sharp negative, the precise effect desired can be easily obtained. If an exact reproduction of a diffused negative is wanted, use another negative with sharp lines and focus, then substituting the negative to be used, as previously suggested.

"Pin on the enlarging board a smooth piece of black paper larger than the whole image projected, in order to prevent possibility of reflection or halation. Replace the white card, holding it in place by means of at least four glass-headed pins well driven in, the corners being better, to hold the card firmly, but allowing it to slide up from its position. Take out the card, cap the lens with orange for slow plates and red for fast plates, cut off all light but the developing light at the tank, take out the plate used and place it in position indicated by the pins. In this way the negative will have been focussed, the right portion selected, and the plate is safe and ready for the exposure. The glass side of the plate will, of course, be next to the black paper, and if for any reason, a reversed negative is desired, such as for single process carbon work, the negative would have been reversed, film side out, in the kit.

"If you have been successful in making bromide enlargements, and have learned the exposure to be given, especially with the negative to be used, the relative exposure for plates will be as follows:—

"For a fast plate, single coated, one-eighth the exposure of bromide paper.

"For a medium fast plate, one-third the exposure.

"For a process plate, the same exposure as bromide paper.

"The quality of the negative to be enlarged from will determine to some extent the kind of plate to be used for producing the

large transparency, in addition to the density or color of the negative determining the exposure. The slow plate transparency, normally exposed and developed, will have considerably increased the density and contrast as compared with the original. The operator will be guided by his own preferences in making the selection. On the other hand, with a heavy original, a fast plate properly handled, will give a transparency in which much of the harshness will have been lost.

"The making of the final negative must also be remembered. A slow plate transparency from a contrasting positive will, under normal treatment, have very heavy blacks and whites in printing from it. A thin, fast plate transparency, and a fast plate negative, will print flat, but full of detail. The photographer who wishes to be supplied for all effects in negatives should have a supply of both fast and slow plates, or else he may prefer to use the medium speed for both positive and negative. It is a prevalent error among professional photographers who make negative enlargements, to have them too dense, and with so much contrast as to give a very hard effect in the prints from them.

"A knowledge of exposure and development will render it unnecessary to keep two kinds of plates on hand. It is a well-known rule that over-exposure and weak development tend to flatness and detail, and under-exposure and strong development tend to contrast and harshness. With some expertness in exposure and development, the photographer may obtain in each process the effect that he desires. In making transparencies it is a good rule to give full exposure and full development, as, with a rapid printing medium (the second plate for the negative), there is little difficulty in having the light penetrate all parts of the transparency. The full exposure and development give the best large reproduction of the original with the least possible loss through the enlarging process. This remark is quite pertinent, for the reason that the transparency is taken out from the developer too soon five times, to where it is once left in too long by the average photographer. It is also a good rule to expose the positive for the high lights, which is equivalent to over-exposing, in order to avoid loss of printing quality.

There is also considerable opportunity for individual taste in the choice of the developer. A good metol-hydroquinone formula, diluted with ten times the quantity of water will, with prolonged development, give a positive which is full of detail, and with fresh chemicals, a negative without the yellow stain which is difficult to estimate in exposing for the negative. Pyro will give a

very rich and beautiful transparency to look through, but it may not produce such a good negative, on account of the difficulty of exposure just mentioned. In developing the final negative, it is best to use metol-hydro with slow plates to obtain detail, and pyro with fast plates, to obtain brilliancy. All of this is, however, to be modified by the effect, whether sharp or diffused, low-toned or brilliant, desired in the prints to be made from the negative. Even these effects are again modified by the printing method and paper to be employed.

After the transparency has been washed and dried it should be examined critically to determine what modifications, if any, should be made to it either to remedy errors or to improve the pictorial effect. If the transparency is backed with a piece of tissue paper or ground glass, it may be seen to better advantage. The modifications decided upon may be made by a competent retoucher, or by the operator, if he understands or will take the pains to learn this kind of work. Intensifications and reductions in part or whole, should be made prior to retouching on account of the coating of varnish used for the pencil work. For a small spot touch the cork with varnish to the place, and with a piece of soft cotton spread it quickly and uniformly as thin as possible. If the whole surface of the negative is to be prepared for pencil work, let a few drops of the varnish fall on the film, and work it out very rapidly and evenly. The coating so prepared will have no effect whatever in printing, which would be the case if the varnish were to be allowed to dry on thick or in patches. The surface is ready for the pencil almost immediately. Retouching on transparencies requires less skill than on negatives, in which the work has to be done in reverse as to light and dark parts. To remove any part of the retouching, rub in a drop of varnish as at first. For darkening more of the surface at one time than could be readily worked over with the pencil, an extremely weak solution of red aniline dye in alcohol may be rubbed on evenly with a wad of soft cotton. For broad effects there is another medium, ground glass varnish, which is to be flowed, not rubbed, over the glass side of the plate. The surface so prepared will take pencil like paper or ground glass. This method is used by some well-known portraitists, who insert backgrounds and other decorations.

A simpler method than any of the above for making modifications on transparencies or negatives is to fasten a piece of smooth, thin paper, such as bond paper, to the glass side of the plate, either by gumming the edges or by fastening the paper to the

plate with lantern-slide binding. The paper will, of course, take all of the lead pencil, lampblack, or crayon work that may be needed, and will not change the resulting negative except by slightly lengthening the exposure. Necessarily, any such broad medium is not applicable to the original negative for the obvious reason that any grain or imperfection in the paper would be magnified and intensified.

(To be continued.)

THE TIDES OF COMETS.

R. S. TOZER.

FOR POPULAR ASTRONOMY

The solar tides of the earth are very insignificant in comparison with its diameter, but suppose it were suddenly transformed into gas and reduced to one millionth of its present weight, thus dividing its tide-resisting power by one million or in effect multiplying the tide-raising power by the same factor. Suppose further the sphere of gas were expanded to a diameter of 250,000 miles, again multiplying the tide-raising power. Suppose the revolution of the sphere on its axis were stopped, freeing the tides from this restraining influence and allowing them to accumulate. Suppose again the earth's orbit were changed to one of great eccentricity like the orbit of a comet. During its approach to perihelion the speed and distance of the earth's fall toward the Sun would be much increased, thus adding to the solar tides.

These changes, which would be necessary to transform the earth into a comet, would practically increase the tide-raising force about 50,000,000 times, raising enormous tides which would increase rapidly as the earth neared the Sun and reach their height at or a little after perihelion. It necessarily follows that there would be great tidal elevations in all of the larger comets; not waves, since comets do not revolve on their axes, but enormous and rapidly accumulating elevations of gas. As is well known, there are disturbances in most comets which correspond to the above but they have been attributed to some kind of magnetic repulsive power exerted by the Sun.

When a comet gets so near to the Sun that the tide-raising power is strong enough to overcome the gravitational pull of the comet on its own outer shell, the part of it farthest from the Sun, having an excess of centrifugal tendency, will travel in a line curved less toward the Sun. If it could be released from the

attraction of the comet at this time it would take a new orbit of less eccentricity than its old one. As the comet proceeds in its orbit, more and more of this portion of it is affected and the extreme portion of the tide, becoming farther removed from the center, is more powerfully affected by the tide-raising force until a tail begins to form.

The particles nearest the Sun, having an excess of central tendency, will fall toward the Sun. As they fall, their velocity will be accelerated until they develop an excess of centrifugal tendency, or in effect, reach a premature perihelion, and rebound upwards toward the main body of the comet. The lines of least resistance for these particles will lie through the outer edges of the head, and as their momentum carries them past the center of the head they are grasped by the outer tide-raising force and added to the tail. The inner tide is therefore limited in its extension toward the Sun by its perihelion and is constantly being added to the outer tide, the extent of which is limited only by its aphelion or by the arrival of the entire comet at its perihelion. Since the comet is much nearer perihelion at this time, and has almost reached its highest speed, the extremity of the inner tide will have a comparatively short distance to go before reaching its own perihelion, and, at the same time, the extremity of the outer tide must travel a vastly greater distance before it can reach an aphelion. For this reason, and because of the addition of the matter composing the inner tide after its rebound from its perihelion, the outer tide is much greater in extent than the inner.

The extremity of the inner tide reaches a perihelion independently of the head of the comet but the extremity of the outer tide cannot under ordinary circumstances reach an aphelion, before the entire comet reaches its perihelion, and, of course, when the comet has passed perihelion, the conditions will be reversed and the gravitational power of the comet will slowly gather in such portion of the tail as has not passed beyond its reach.

As the extremity of the tail is relatively rising it may be relatively retarded just as the comet itself will be retarded when it is rising toward its aphelion. In the case of the tail, the result will be, of course, a backward curvature.

In spite of the fact that magnetic repulsion is utterly inadequate to account for all the disturbances noted in comets when nearing the Sun, it is highly probable that this force, in combination with chemical action of the sunlight, plays a part in forming and modifying the tides.

The division of Biela's comet shows that it is possible for a body of low density to be torn in half by tidal stress and would seem to favor the present theory of the origin of the Moon. It does not however throw any light on the difficulty of accounting for the Moon's orbital motion.

TOTAL SOLAR ECLIPSE OF AUGUST 30, 1905.

During the weeks that have elapsed since the total solar eclipse of August 30th the general results obtained by the principal observing parties have been collected, though in some cases observers are unwilling to permit the publication of any account until their full reports shall be ready. In the meantime the following brief summary of results obtained by the various expeditions is culled from reports sent to POPULAR ASTRONOMY, and from *Knowledge and Scientific News*, *Nature*, *The Observatory*, and *London Times*.

Arranging the reports in the order in which the Moon's shadow visited them, Labrador was the location of the most westerly expeditions. Sir William Macgregor, the Governor of Newfoundland was at Cartwright, where also was a party from the Lick Observatory. Another party of Canadian observers under Dr. King was at Hamilton Inlet, at which point was also Mr. E. W. Maunder. His telegraphic report, "Sky quite cloudy, no results," as far as known, sums up the situation on this side of the Atlantic.

Passing on to Spain, Burgos was the first station, and here included in the large concourse of observers, was the King of Spain. The weather conditions seem to have varied considerably with the locality, for Mr. Evershed who had set up a very fine prismatic camera near Burgos telegraphed "Thick clouds, no results," but some observers seem to have had unexpected good fortune. From a report in a Southport paper by Mr. E. D. Benson, it seems that at twenty minutes to one the sky was completely overcast and rain was falling, but almost miraculously, five seconds before totality the Sun passed into a gap between the clouds and the corona and prominences were well observed. Mr. Benson remarks that the temperature dropped some nine degrees during totality, that Mercury and Venus were visible, but general observation of stars was impossible owing to clouds in the sky, and that shadow bands were seen flickering along the ground after totality. The same report is also responsible for the statement that the night before the eclipse the price for bed and breakfast in Burgos was four pounds English money! The reports from

the east coast of Spain, beginning with the northerly points are as follows. Farther Cortie was at Vinaroz, assisted by Mr. Adrian Liddell, Mr. L. Cafferata, and Mr. G. de Aquilera. Father Morford, of Saltash, was also of the party. Father Cortie says: "In spite of light clouds that passed over the Sun at the beginning of the eclipse, we have been on the whole very successful. We have six beautiful pictures of the corona taken with the long focus (19 ft. 4 in.) 4-inch lens belonging to the Royal Irish Academy. The scale is 2.1 inches to the solar diameter. We also have four plates giving images of the corona and the spectrum of prominences and corona on the same plates taken with the direct image and first order spectrum of a Thorp transmission grating and a 3-inch quartz lens." "At the Observatory of Tortosa, north of Vinaroz, there was a large party, besides the observers attached to the establishment, under Father Cirera. The sky was clear there for about a minute and a half during totality, and the observers obtained four good photographs of the corona, several fine drawings, and a great stock of electrical, magnetic, and meteorological data. At the foot of the mountain at Tortosa the French official party under M. André had clouds, and at Castellon, also on the east coast, but south of the central line, where Professor Callendar was in charge of one of the official parties, and where Professor Alex. Herschel and others had located themselves, totality was entirely obscured by clouds, but the first and last contacts were observed in clear sky, and good records of radiation and temperature were obtained."

Mr. J. Y. Buchanan, F. R. S., at Torreblanca, had the luck to see the eclipse in quite a clear sky. He describes the corona as being very bright, and with clearly defined edges, like fortifications. The light generally was so great that he was unable to detect any stars except Venus. The prominences, described as a violet color, were well seen at the beginning and end, but were not visible at the middle of totality. This should give a practical clue to the height of the prominences. The party at Oropesa, under Professor Callendar, of the Royal College of Science, was unfortunately entirely precluded from making any observations on account of the clouds.

Professor Moye of Montpellier was also in this locality and his report in full will be found in the General Notes of this issue.

Several British observers unwilling to experience the mysteries of out-of-the-way Spanish hostelries and long railway journeys, took the more comfortable, if less business-like, method of going in large steamers. Two liners, timed to be well within the limits

of totality at the moment of the eclipse, had arranged to heave-to to enable passengers to have a good view of the phenomenon. In both cases the atmospheric conditions were fairly good, and if no very exact or especially valuable observations were made, at all events the observers were well satisfied with what they saw. The "Orotona" situated on the central line in the Mediterranean, near the Spanish coast had an excellent view of the eclipse. Professor Joseph Larmor notes that the streamers were not all radial, and that the most prominent were those at 45 degrees from the vertex to the left, and a long thin streamer 61 and one-half degrees from the lowest point to the left. The lightness of the eclipse was marked and disappointing, but Venus and Regulus were seen and the whole black bands—dark strips about six to eight inches wide, distance apart about eighteen inches—were seen after totality rippling along the deck a little faster than could be followed by the eye. They were parallel to the strip of the Sun after totality, and travelled in the direction of the shadow. The prominences were reported as "rose-color" with bases yellow, by another observer, the corona of a "soft pearly hue" had streamers projecting about two diameters, two pairs above and below the Sun. The steamer "Arcadia" also carried an observing party, equipped with small telescopes, spectroscopes and cameras. The vessel hove-to near the Columbretes Rocks, south of Majorca in perfect calm. Though clouds passed over the Sun there were intervals of perfect clearness. Baily's beads were seen, as were the shadow bands. The conclusions were that the corona was very compact, and very bright and of a silvery hue. Only one ray stretched out conspicuously from the corona, but four or five minor streamers also existed. The prominences were said to be paler than usual. The thermometer dropped about ten degrees.

In the Balearic Islands various conditions of weather prevailed. The party near Palma under Sir Norman Lockyer included Dr. J. W. S. Lockyer, Mr. C. P. Butler, Mr. Howard Payn, Mr. F. S. McClean, and a number of officers and men from H. M. S. "Venus." The first contact and almost the whole of the partial phase was observed in clear sky but at two minutes past one, G. M. T., clouds gathered and covered the Sun; these lasted in various thickness until totality began, and all the total phase was seen under a veiling cloud. Nevertheless the inner corona was seen as a brilliant circle of silvery light, shading here and there to blue, and the prominences were quite visible. Neither Mercury or stars were seen because of the clouds which covered

them, but Venus was seen by several persons. Some who looked carefully for shadow bands saw them but vaguely, if at all, though the preliminary report from Sir Norman Lockyer's camp says that the observers there gained a great deal of information about this phenomenon. This same report, while lamenting the clouds, states that some results were obtained, both spectroscopic and photographic, Mr. McClean having obtained a fine photograph of the corona with sharp detail and good extension, and Mr. Butler an excellent picture of the lower corona, the solar diameter being eight and one-eighth inches. In some other parts of the island not far from Palma observers were more fortunate. A party of Jesuit Fathers under Father Algué, the Director of the Manila Observatory, had a fine sky, and secured good photographs and drawings. In the center of the town of Palma several English astronomers, including Mr. Crommelin were on the roof of the Grand Hotel. There were some clouds, but fairly good observations were made during the period of totality.

The African reports show better cloud conditions. Phillipville in Algeria, whither the Solar Physics Observatory of England first planned to go, had perfect weather. At Guelma, also, the conditions were most favorable. Mr. Newall made many successful observations with the great spectroscope from Cambridge, England. The corona was here reported as being very bright, not extensive, and uniformly distributed about the Sun. The red protuberances were well seen as were also Baily's beads. Mercury, Venus and Regulus are reported as seen. Thirty-one photographs were taken by the Algiers mission. The temperature fell five degrees, C. Shadow bands were well observed.

At Sfax, in Tunis, was the party from Greenwich, under the Astronomer Royal, assisted by the crew of H. M. S. "Suffolk." A French party was also here, under M. Bigourdan. Though partially cloudy, the eclipse was fairly well observed and photographed. The corona, as seen here, is reported to have been of the characteristic *maximum* type, with streamers extending to as much as two diameters from the disc, and "of a rosy color." The following account appeared in the *London Times*:—

"The day of eclipse was by much the worst day that was met with. It broke cloudy, cleared a little in the forenoon, but left a nasty haze about the Sun that was reinforced as the time approached by light detached clouds, blowing from the north-west. The Sun was never hidden for more than a few seconds, but it was unpromising for the big telescopes. As the Moon crept over

the Sun's face the temperature, which had been at 90 deg., fell slowly to 84 deg. There was no sense of chill in the air. The party of observers was reinforced by officers and men from the *Suffolk*, told off for watching attendant phenomena, for counting seconds from a metronome, or other help. The light grew weird, and dancing bands of shadow were seen upon the ground and walls. Venus shone out, and soon afterwards Arcturus. Sir William Christie watched the diminishing crescent of the Sun's disc on the ground glass of the Thompson Camera, and called out "Stand by" 20 seconds before the disc should disappear. All was ready. Then occurred a delay, unaccountable at the moment, but clear enough afterwards. There seemed no definite beginning to the eclipse. The crescent never wholly disappeared, or, rather, it merged into a magnificent group of prominences spread over an arc of almost 30 degrees, near the spot where the last of the Sun's true disc was seen. They must have been of immense height, and it seemed at least 30 seconds before they were hidden by the advancing Moon. At the same time, gradually too, emerged the corona. Observers who have seen many eclipses say it was but a poor corona. To others it did not seem so. In place of the Sun's crescent, an inky black disc hung in the sky, with a great span of rosy prominences east of its vertex, and at all other parts of the circumference streaks and streamers of pale but defined substances set with the strangest irregularity, brilliant round the edge of the disc, and lost to the eye some two diameters distant. Many observers saw a rosy tint in it. Others called it a pure silver or aluminium gray. It was most unmistakably of the type associated with the Sun-spot *maximum*. Many stars were visible, though the sky was never very dark. Too soon its 200 seconds were gone, and with amazing brilliance the Sun's disc began to reappear. Nothing remained but to collect results, and to ascertain how much the indefinite beginning had spoilt the plan. It is hoped that it interfered but little. Most observers took successfully as many as seven photographs out of eight. How far the haze and diffused light of the sky may affect these can be answered only when the plates are developed at Greenwich." From another source we learn "that the photographs of the corona and the spectrum plates taken by the Astronomer Royal's expedition are coming out well."

Tripoli was the location selected by Professor David P. Todd of Amherst College Observatory. From his report the following extracts are made.

"Our eclipse took place in the midst of the fierce heat of the

Gibleh, or Sahara sirocco; but an hour or two before totality the wind very fortunately changed, and brought skies of the highest possible optical transparency. There was no wind, and the conditions, except for the intense heat, which we momentarily feared would snap our great cameras, were the most nearly perfect imaginable at a sea-level station.

Unfortunately, on account of leaving home at very short notice, we brought no spectroscopic outfit, and our efforts were directed solely toward coronal photography with automatic and semi-automatic coronagraphs, and to exposure of plates for the slightly suspected intra-Mercurial planet. Other branches of our work related to coronal sketches, both with and without occulting discs, and to shadow bands observations, both optically and photographically."

"The observation of shadow bands were conducted by parties organized by Mrs. Todd and Miss Todd, and will be reported to my friend Mr. Lawrence Rotch, of Blue Hill, at whose request they were made. These bands were seen as early as ten minutes before totality, and had many remarkable and pronounced peculiarities. They were wavering and narrow, moving swifter than one could walk, at right angles to the wind, their length with it, and waxing and waning five times during the eight minutes preceding totality.

The coronal sketches revealed nothing out of the ordinary. Extended rays beyond the occulting discs were looked for eagerly, but the disc (8 inches diameter at 35 feet distance) covered everything. The sky and general illumination were exceptionally bright. Totality as predicted was 3m. 9s. in duration; as observed 3m. 6s.

Our chief and largest instrument was a photographically corrected lens by Clacey, of 12 inches full aperture. To this was attached an orthochromatic screen for photographing Baily's beads, and a Burckhalter occulter as described by the writer four years ago in the *Monthly Notices*. Of the results obtained with this instrument I shall write elsewhere; about twenty exposures were made with it, and the beads are excellently shown. The occulter was only in part successful.

Alongside it were the large Clark cameras, containing a pair of 3-inch lenses of 11 feet 4 inches focus, which took plates, on which are a great number of stars, not yet fully examined. Owing to the unexpected brilliancy of the sky, the plates were exposed longer than would seem to have been wise. Everything to the eighth magnitude seems to have been caught, however.

A third instrument was a 3½-inch Goerz doublet of about 18

inches focus, from which I removed the back lens, increasing the focal length to 33½ inches. This was attached to one of the automatic movements used in my previous expeditions of 1896, 1900, and 1901. It was geared up to a rate of 265 photographs during the 189 seconds of totality, the exposure being about ¼ second for each. Most of these pictures are very good. The corona was much less impressive, it strikes me, than other coronas I have seen —1878 and 1900 in clear skies, and 1887, and 1889, 1896, and 1901 in clouds; in fact, the shadow bands and Baily's beads seem to have been rather more interesting to the general observer than the corona itself."

At Assuan, up the Nile, were stationed three national expeditions—British, American and Russian. Egyptian skies are proverbially clear, but there was a certain amount of haze over the sky, which detracted from a clear view of the corona. The corona appeared small with its longest streamer to the south-east, about two diameters or less in length, and three shorter ones. The change of temperature was very slight. The *Times* of London reports "The British party, with invaluable assistance from Captain Lyons and the officers of the Survey Department, obtained five ordinary exposures with an astrographic telescope, besides one with a geeen color screen and one enlargement, six photographs polarized by reflection in a horizontal plane, and two in a vertical plane. Mr. Günther, of Magdalen College, Oxford, obtained six plates with a Goerz lens for comparison with similar plates taken in Labrador. Mr. Reynolds's 120-ft. reflector was mounted under unforeseen difficulties, at short notice, with the able assistance of Mr. Keeling. Professor Turner, of Oxford, assisted by Mr. Bellamy, made special observations on the light of the corona.

The party from Lick Observatory, under Professor Hussey, was equipped exactly like their party in Labrador. These two stations being situated so far apart that the times of totality differed by two and one-half hours, it was hoped that any change in the corona during this period might be detected. Professor Hussey developed his plates on the spot and reports them all satisfactory. They also made some interesting observations of shadow bands. Their velocity was quite moderate and the direction of motion was the same before and after totality, agreeing with that of the wind, but there was almost a dead calm at Assuan.

The study of the shadow bands was given special notice in the eclipse report published by *The Observatory* for October, and its summary we append.

"It will be noticed that in the above summary care has been taken to give full details of the observation of shadow-bands, which are long dark bands, or sometimes lines of patches, separated by white spaces which are seen on the ground or sides of buildings just before and just after the total phase of an eclipse, moving rapidly. Observations hitherto made have been quite discordant, and the cause of the phenomenon is not known with certainty, although there are theories. One of these assumes that the bands are a diffraction effect when the Sun becomes a narrow strip; another theory is described in the following extract from an article on the subject by Professor Cleveland Abbè, which (written in 1887) appeared in the *American Monthly Weather Review* for 1900, May:—

'Meteorology has perhaps not much to expect from observations of the barometer and the wind during a total solar eclipse, but it has considerable interest in the shadow-bands. It seems quite plausible that the explanation of these is to be found in the interference of two pencils of sunlight that have respectively passed through adjacent portions of air of slightly different densities. This should not be called a diffraction phenomenon, though it does occur when a thin sheet of light from the edge of the Sun passes the edge of the Moon at the moment preceding totality. Undoubtedly such a slender beam of light may cause diffraction phenomena, but, if so, the diffraction bands would necessarily move onward over the Earth's surface with the same relative speed as that of the Moon and the Earth, namely approximately a mile a second, whereas the observed shadow-bands have a velocity of only a few feet or yards per second. On the other hand, the bands may be considered as phenomena of interference of rays of light slightly inclined by reason of the irregular refractions in a nonhomogeneous atmosphere, and they must therefore have such characteristics as are impressed upon them by the condition of the atmosphere at the time; their horizontal movement must correspond nearly with that of the winds and upper currents in the atmosphere. In fact, we need not necessarily speak even of interference phenomena. Every small mass of descending dense air constitutes a rough sort of lens prism; the beam of light that passes through it must be deflected, and the atmospheric mass casts a shadow on the ground, like a lens or prism of glass. Such phenomena may be seen when the air is very much disturbed even in ordinary full sunlight, but become much better defined when the Sun's disc is reduced to a slender crescent as during the few seconds preceding and following totality.'"

ON THE POLARIS VERTICAL CIRCLE METHOD OF OBTAINING TIME WITH THE SURVEYORS TRANSIT.

G. O. JAMES

FOR POPULAR ASTRONOMY.

In his paper *The Polaris Vertical Circle Method of Determining Time and Azimuth*,* Professor Seares has adapted the method to the engineers transit, and has given the necessary formulae for the reduction. Where the object is to obtain as accurate a value of the time as is possible with the instrument at hand his method is all that can be desired. When, however, an approximate value of the chronometer correction is wanted, as for instance in azimuth work, the following method of reduction will be found much shorter.

The method of observing is the same. Polaris is bisected by the vertical thread of the instrument and the time noted, *without changing the azimuth*, the telescope is then rotated about the horizontal axis and the time of transit of a southern star is observed. For this is necessary to know thelocal sidereal time to within five or ten minutes so as not to wait too long for the star. It is also necessary to know the latitude roughly—to the nearest minute is sufficient—in order to make the setting for the southern star. If a mean time chronometer is being used, set:

T_c = Chronometer Time,
T = Local Mean Time,
$\Delta'''T$ = Correction required to reduce the mean interval T to sidereal interval,
θ = Local Sideral Time,
$\Delta''\theta$ = Correction required to reduce the sidereal interval θ to mean interval,
θ_1 = Sidereal Time of Greenwich Mean Noon,
λ = Longitude West of Greenwich,
ΔT_c = Chronometer Correction on Local Mean Time.

The sidereal time at instant T is then:

$$\begin{aligned}\theta &= T + \Delta'''T + \theta_1 + \Delta'''\lambda \\ &= T_c + \Delta T_c + \theta_1 + \Delta''' (T + \lambda)\end{aligned}$$

If then we write

$$\theta' = T_c + \Delta' T_c + \theta_1$$

where $\Delta' T_c$ is an assumed value for ΔT_c, this will be a sufficiently close value of the local sidereal time to find the southern star, for the term

$$\Delta''' (T + \lambda)$$

* Bulletin No. 5, Laws Observatory, University of Missouri.

is always less than 5^m, and the interval by which the star is early or late due to the telescope not being quite in the meridian is never greater than 10^m for latitudes below 60°.

The chronometer time at which the southern star may be expected is then

$$T_c' = \alpha - (\Delta' T_c + \theta_1)$$

If Polaris is west of the meridian, the star will transit early, and in this case it is well to begin to watch for it about 10^m ahead of time.

The setting for the southern star is

$$z = \phi - \delta$$

where

ϕ = Latitude of observer
δ = Declination of star
z = Zenith distance of star.

This value of the zenith distance to the nearest minute is sufficient for the setting, and refraction may be neglected, not being sufficient to throw the star out of the field.

For the purpose of *finding* the star, the right ascension and declination may be taken from the list of Mean Places of Standard Stars, while for the reduction and computation of the result, the right ascension and declination should be taken from *Apparent Places of Standard Stars*. Both of these lists are published in the *Ephemeris* every year.

For the reduction, set

T_c = Chronometer Time of bisecting Star
α and δ = Right Ascension and Declination of Star
p and z = Polar and Zenith Distance of Star
a = Azimuth of Star
t = Hour Angle of Star
ζ = Observer's Colatitude

Both a and t are to be taken positive when increasing with the time,

Let subscript $_0$ refer to Polaris.

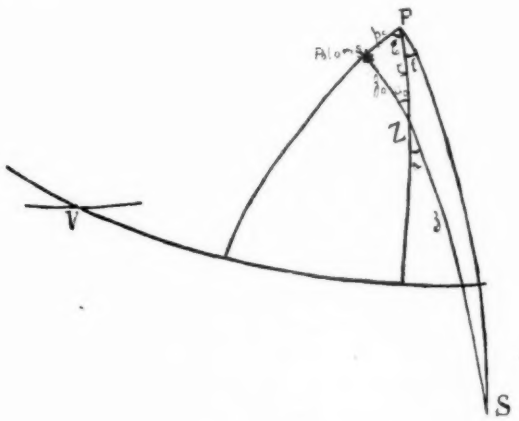
Then

$$\begin{aligned} t_0 &= \theta_0 - \alpha_0 \\ t &= \theta - \alpha \\ t_0 - t &= (\alpha - \alpha_0) - (\theta - \theta_0) \\ &= (\alpha - \alpha_0) - (T_c - T_{c0}) - \Delta'''(T_c - T_{c0}) \end{aligned}$$

In the figure let

Z = Observer's Zenith
P = North Celestial Pole
S = Southern Star
V = Vernal Equinox

From the figure



$$\frac{\sin t}{\sin z} = \frac{\sin a}{\sin p}$$

$$\frac{\sin t_0}{\sin z_0} = \frac{\sin a_0}{\sin p_0}$$

Now $a = -a_0$

and $z = \phi - \delta$ very nearly.

Hence

$$\sin t = -\sin p_0 \sin (\phi - \delta) \sec \delta \sin z_0 \sin t_0$$

Since t and p_0 are both small we may write:

$$\begin{aligned} t &= -p_0 \sin (\phi - \delta) \sec \delta \sin z_0 \sin t_0 \\ &= -q_0 \sin t_0 \qquad \text{say,} \end{aligned}$$

where

$$q_0 = p_0 \sin (\phi - \delta) \sec \delta \sin z_0$$

Again

$$\phi = h_0 + \epsilon_0$$

where h_0 is the altitude of Polaris and ϵ_0 is a small correction depending on t_0. In as much as ϵ_0 tabulated on the last page of the *Ephemeris* with t_0 as argument, we may write

$$90 - z_0 = \phi - \epsilon_0$$

and then

$$q_0 = p_0 \sin (\phi - \delta) \sec \delta \sec (\phi - \epsilon_0)$$

Since t is small an approximate value of t_0 is given by

$$t_0' = (a - a_0) - (T_c - T_{c0}) - \Delta''' (T_c - T_{c0})$$

which may be used in computing q_0.

Hence

$$q_0 = p_0 \sin(\phi - \delta) \sec\delta \sec(\phi - \epsilon_0')$$

where ϵ_0' corresponds to argument t_0'.

From this

$$t' = -q_0 \sin t_0'.$$

Using this value of t' there follows,

$$t_0 = t_0' + t'$$

and finally:

$$t = -q_0 \sin t_0.$$

The local sidereal time of transit of the southern star is

$$\theta = \alpha + t.$$

If then, we write,

$$\theta_c = T_c + \Delta''' T_c + \theta_1$$

we have,

$$\Delta\theta_c = \theta - \theta_c.$$

Collecting the necessary formulae for the reduction we have,

$$\begin{cases} t_0' &= (\alpha - \alpha_0) - (T_c - T_{c0}) - \Delta'''(T_c - T_{c0}) \\ q_0 &= p_0 \sin(\phi - \delta) \sec\delta \sec(\phi - \epsilon_0') \\ t' &= -q_0 \sin t_0' \\ t_0 &= t_0' + t' \\ t &= -q_0 \sin t_0 \\ \theta &= \alpha + t \\ \theta_c &= T_c + \Delta''' T_c + \theta_1 \\ \Delta\theta_c &= \theta - \theta_c \end{cases}$$

The following example will illustrate the method.

Station: W. U. Date: May 7, 1905.

Observer		Beals		Traber	
Star		α Virginis		π Hydrae	
T_{0c}		$10^h\ 15^m\ 17^s$		$10^h\ 53^m\ 45^s$	
T_c		10 20 33.5		11 2 11.	

Reduction.

$p_0 = 4329''$

α	13^h	20^m	$13^s.0$	14^h	1^m	$00^s.0$
α_0	1	34	17.0	1	24	17.0
$\alpha - \alpha_0$	11	55	56.0	12	36	43.0
$-(T_c - T_{0c})$		−5	16.5		−8	26.5
$-\Delta'''(T_c - T_{0c})$			−.9			−1.5
t_0'	11	50	39	12	28	15
	177°	39.′8		187°	3.′8	
ϕ	38	39		38	39	
δ	−10	40.1		−26	13.6	
ϵ_0'	1	12.1		1	11.7	
$\phi - \delta$	49	19.1		64	52.6	
$\phi - \epsilon_0'$	37	26.9		37	27.3	
$\log(-p_0'')$	3.63639n			3.63639n		
$\sin(\phi - \delta)$	9.87986			9.95684		
$\sec\delta$	.00757			.04718		
$\sec(\phi - \epsilon_0')$	.10023			.10027		
$\log(-q_0)$	3.62405n			3.74068n		
$\log\sin t_0'$	8.61035			9.08979n		

log t'	2.23440n			2.83047			
t'	$-171.''6 = -2.'9$			$676.''8 = 11.'3$			
t_0	177°		$36.'9$	187°			$15.'1$
log sin t_0	8.61924			9.10206n			
log t	2. 24329n			2.84274			
t	$-175.''1 = -11.^s7$			$696.''2 = 46.^s4$			
θ	13^h	20^m	$1.^s3$	14^h	1^m	$46.^s4$	
T_c	10	20	33. 5	11	2	11. 5	
$\Delta'''T_c$		1	41. 94		1	48. 78	
θ_1	2	58	37. 94	2	58	37. 94	
θ_c	13	20	53. 4	14	2	38. 2	
$\Delta\theta_c$			-52.1			-51.8	
Mean			-52.0				

If the observer's longitude is approximately known, the chronometer correction on local mean time may be obtained as follows:

for $\quad \theta = T + \Delta'''T + \theta_1 + \Delta'''\lambda$
and $\quad \theta = T_c + \Delta'''T_c + \theta_1 + \Delta\theta_c$
whence $\Delta T_c = T - T_c = (\Delta\theta_c - \Delta'''\lambda) - \Delta''(\Delta\theta_c - \Delta'''\lambda)$

At the station above $\lambda = 6^h\ 1^m +$

$\Delta\theta_c =$		$-52.^s0$
$\Delta'''\lambda =$		59. 30
$\Delta\theta_c - \Delta'''\lambda =$	-1^m	51. 30
$\Delta''(\Delta\theta_c - \Delta'''\lambda) =$		$-.30$
$\Delta T_c =$	-1	51 .0

This method of obtaining the chronometer correction on local sidereal time is especially useful in an approximate determination of latitude and azimuth.

If the altitude of Polaris is measured at the instant T_c, then

$$\theta_c = T_c + \Delta'''T_c + \theta_1$$
$$\theta_0 = \theta_c + \Delta\theta_c$$
$$t_0 = \theta_0 - \alpha_0$$

The latitude is given by

$$\phi = h_0 - p_0 \cos t^0 + \tfrac{1}{2}p_0''^2 \sin 1'' \sin^2 t_0 \tan h_0$$

and the azimuth by

$$a_0 = p_0 \sin t_0 \sec(\phi - \epsilon_0)$$

The first of these formulas is obtained by developing ϕ in a power series in p_0, while the second is obtained immediately from the figure above.

Washington University,
Oct. 1905.

A. G. C. 6886. STAR HAVING A LARGE PROPER MOTION.

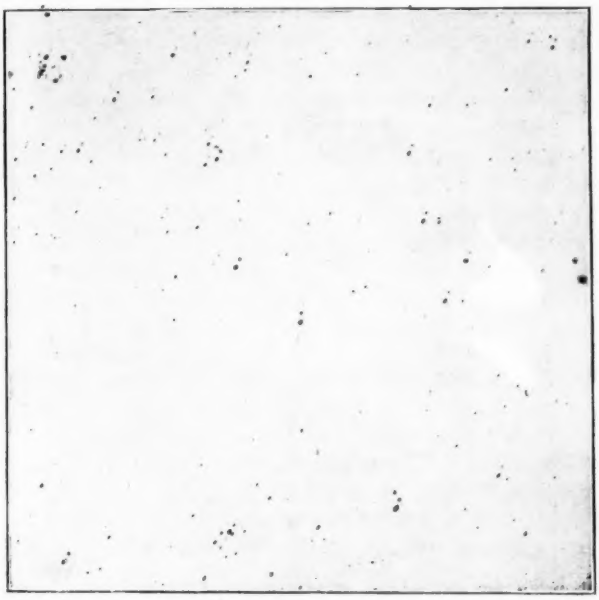
EDWARD C. PICKERING

The method of superposing photographic plates, taken on different dates, upon a glass positive covering the same region, used

for the discovery of variable stars as mentioned in Circular 79, is valuable as a means of detecting any other obvious changes in the region. In Circular 96, announcement was made of a star in the Small Magellanic Cloud which was found in this way to have a large proper motion. During a recent examination of the Large Magellanic Cloud, the star A. G. C. 6886, magn. 8.5, was found by Miss H. S. Leavitt to have moved noticeably, between April 11, 1898, and December 5, 1904. An examination of the different catalogues containing this star, confirms its rapid motion. Measures of its position have been made on Plate B 5720, October 12, 1890, exposure 57^m, and on Plate B 34996, October 21, 1904, exposure 10^m, both taken with the 8-inch Bache Telescope. The positions derived from these measures, and those in the different catalogues, reduced to the epoch 1875.0, are given in Table I. The name of the catalogue or photographic plate and the number of the star are given in the first column, and the date of observation, expressed in years and hundredths, in the second. As no dates are assigned for the observation in Brisbane's Catalogue, beyond the statement that they were made principally in the years 1822, 1823, 1824, 1825, and 1826, the epoch of the catalogue, 1825.0, has been assumed as the time of observation. The observed right ascension and declination are given in the third and fourth columns. The declination as given in Brisbane's Catalogue is 5′ too far north, and a correction of this amount has been applied. Brisbane 1065 has the correct declination but the wrong right ascension. In discussing these positions, for the purpose of determining the amount of the star's proper motion, the catalogue of Brisbane was omitted on account of these uncertainties as to time and position. The Cape Photographic Durchmusterung was also omitted, because the positions were not sufficiently precise for comparison with other catalogues. Assigning equal weights to the remaining five positions, it has been found that the motion in right ascension may be closely represented by the formula $\Delta\alpha = -0^s.066t$. The fifth column gives the right ascension, corrected by this formula, in seconds of time following $5^h\ 45^m$. The motion in declination may be represented by the formula $\Delta\delta = +1''.14t$, and the corrected declination is given in the sixth column in seconds of arc south of $-70°\ 13'$. The residuals from the means of the corrected right ascensions and declinations are given in the seventh and eighth columns. The average values of these residuals, omitting Brisbane's Catalogue and the Cape Photographic Durchmusterung, are $\pm 0^s.06$ and $\pm 0''.2$. The annual proper motion, as given above, is in

right ascension, $-0^s.066$, in declination $+1''.14$, in a great circle, $1''.28$.

For the purpose of showing this motion, Plates B 5710 and B 34996, mentioned above, were superposed, the star images not quite coinciding. The two plates were then enlarged to a scale



of $40''. = 0.1$ cm., as shown in the accompanying figure. Two images of each star are seen, the brighter of each pair belonging to the earlier of the two plates. The position angles of these two images are sensibly the same for all stars except A. G. C. 6886, seen in the centre of the figure.

The total number of stars clearly shown on the original negatives is about three hundred thousand. It is probable that none of these, except A. G. C. 6886, have an annual proper motion exceeding three quarters of a second.

Harvard College Observatory
Circular 105.

TO CARE FOR A TELESCOPE.

W. W. PAYNE

FOR POPULAR ASTRONOMY.

We have received requests several times, in the recent past, from amateurs, asking for information in regard to the care of a telescope.

We are always glad to make this publication of use to those beginning the practical study of astronomy, no matter how simple or common place that beginning may be, provided those seeking such information will earnestly and faithfully make the most of it for themselves and for others.

The amateur usually has a three or four-inch telescope with a portable mounting which is strong enough to be steady, and light enough to handle easily when it is to be used in observation.

Proper care for the mounting is to keep it clean and well oiled. This part of the telescope usually consists of wood, brass, steel, nickel or some other metals. If the wood is hard I would not varnish it, but would use an oil filling, or a little clear good oil occasionally, with a thorough rubbing. The wood will then be protected and keep its lively appearance indefinitely. If the wooden parts have been stained and varnished by the makers, it may be best to follow the example so set for the owners when the instrument was new. The brass parts of the telescope need more care than they usually get, if the instrument is to carry its good looks along with its working ability. We call attention to this point for several reasons, that ought to weigh with amateurs. During the last few years we have helped to sell more than two score of small second-hand instruments. As far as we remember, in all cases there were good reasons for wishing to sell them. The condition of the telescope is a prime factor either in its sale or in the pleasure of its continued use. An instrument having an old and worn look is liable to be treated as it looks, and its days of usefulness may be considerably shortened without any reason except that it must be useless because it looks old.

If the brass work has not been well lacquered, or if it is not kept clean, the effect of dust and use will soon dull the lacquer or even eat it away, giving it a very unsightly appearance, that will cause its owner to feel that he has really neglected delicate and valuable property. If it is not his own but put in his care the effect of such neglect ought to disturb his conscience much more keenly.

The care of the object glass is very important. It should be kept clean and it should always be protected from danger by thoughtful attention when in use, or when the telescope is set aside for safe keeping. Those who have experience in the care of telescopes differ somewhat in their advice to amateurs in regard to how object glasses should be cleaned when they have become tarnished or stained or covered by very fine dust which is not easily removed. If the surfaces of the objective need to be wiped the camel's hair brush, wash leather, clean cotton, linen or silk cloth have been safely used. The main thing to bear in mind is that whatever material is used, it should itself be clean and soft, and when applied to the finely polished glass surfaces of the objective to remove dust or stains, it should be done carefully, that the rubbing or brushing should not cause scratches, for slight scratches on the polished surfaces will seriously disturb the work of the objective. When all dust particles are removed the surfaces of the glass may be safely wiped without fear of harm. Sometimes the glass surfaces may have acquired stains of some kinds which may not be so easily removed as already indicated. It will then be necessary to wash them. At Goodsell Observatory when the lenses need washing on account of stains from grease or other substances, soft water with a fine quality of soap is used. If the stains are so persistent that this means will not remove them, a little pure alcohol applied to the surface at such places will usually be sufficient.

Amateurs often have trouble in using small portable telescopes when observing in the open air, at night, with the gathering of dew on the objective. This occurs in the case of sudden changes of temperature. When the glass is dewed, work can not go on. Never leave the object glass of a telescope wet when it is put away, for by so doing one is likely to find troublesome stains upon it, as a consequence. It may take time and patience to dry it properly, but that should be the rule in the care of all glasses large or small. If the observer is provided with nothing more than a lamp and a fan, the task of drying a dewed glass will not be great.

It might here be suggested that for small portable instruments a dew cap for common use is desirable. Three or four-inch glasses should be provided with metal dew-caps by the makers. If, however amateur observers have instruments without such caps, pasteboard ones can be easily made that will answer the purpose nearly as well. At Goodsell Observatory while working on a latitude problem for a month quite continuously with a two-inch

telescope, the dew-cap was regularly used every night while observing in the open. When observing in the Rocky Mountains at an altitude of nearly 5000 feet above sea level during the months of July and August, it was necessary to use the dew-cap on the 8-inch photographic telescope constantly because of the rapid change in temperature in the early morning hours.

If the objective is large and the double convex lens and the plano-concave lens are placed very close together in the cell by the makers, water on the outside of the objective while in place may cause considerable trouble. For if it finds its way behind the forward lens and by the aid of capillary attraction creeps between the two lenses, the beautiful figures so formed which remind one of the delicate frost pictures on window glass in cold weather at once destroy all work by the objective until the water is removed.

Especial care must be exercised in handling the lenses under such circumstances because of the strong adhesion of the inner surfaces, possibly increased by the pressure of a film of moisture. The sixteen-inch lenses belonging to the large telescope of Goodsell Observatory have been in such a condition two or three times since 1887. When the objective was taken from its cell, as it stood on its circumference, it was all that two men could do to separate its lenses, in order to remove the moisture that came up between them.

From what has been said the inexperienced person in the possession of a small telescope will readily know what to do in caring for the eye pieces of his instrument. The chief attention to these parts is to keep them clean. In cold weather the breath of the observer is likely to deposit moisture on the eye piece, and by this means to blur the image more or less that is under observation. It is usual to wipe the outer surfaces of the lenses with a linen handkerchief, and this means is safe enough if the rubbing is not too hard, and the handkerchief is free from dust particles to avoid scratching.

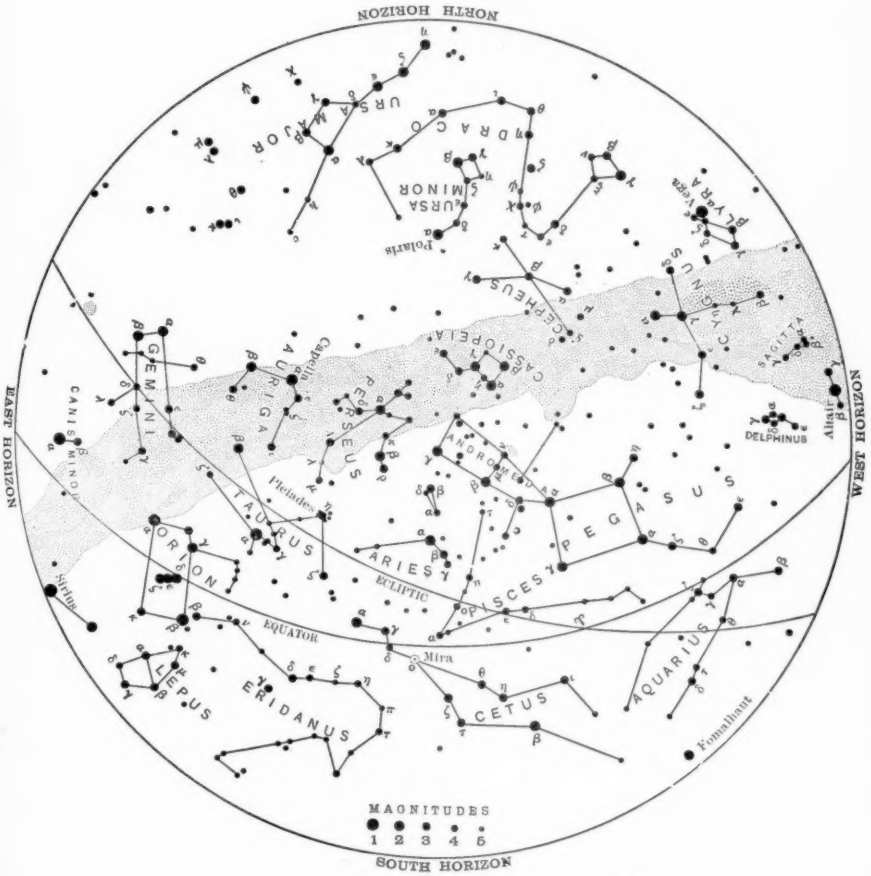
While speaking of the metal parts of the mounting it should have been said that some observers prefer vaseline to other forms of oil, both for lubrication and for protection of bright metallic surfaces from oxidation, the chief reason being that vaseline does not leave the surfaces in a gummy state as other oils sometimes do.

If these few hints on the care of instruments, that have been hurriedly penned, may prove of service to any amateurs to help them to care for their telescopes well, the purpose of them will fully meet.

PLANET NOTES FOR DECEMBER, 1905.

H. C. WILSON.

Mercury will be at inferior conjunction on December 15 and so will be visible to the naked eye only on the first three or four days as evening star and on the last three or four days of the month as morning star. The planet will be at perihelion on December 14. On December 21, at 8:00 P. M. central standard



THE CONSTELLATIONS AT 9 P. M. DECEMBER 1, 1905.

time, Mercury and Venus will be in conjunction in right ascension, but both planets will then be invisible.

Venus is morning star, but is now getting too near the Sun to be observed. She is on the farther side of the Sun and will be at superior conjunction early

next year.

Mars is in poor position for observation being seen low down in the southwest in the early evening. The apparent diameter of the disk of the planet is only 6″, so that the markings of its surface are not at all conspicuous. Mars and Saturn will be in conjunction December 11 at 10:00 P. M. central standard time, Mars being then 30′ north of Saturn.

Jupiter is a splendid object in the eastern sky in the early evening. The planet is almost due south of the Pleiades and at meridian passage reaches an altitude of over 60° in our latitude. On nights when the seeing is good the telescope should reveal a great variety of detail in the ruddy mottled belts of the planet.

Saturn is past its best position for observation this year, but may be seen toward the southwest in the early evening.

Uranus is behind the Sun, conjunction occurring December 26.

Neptune will be at opposition December 30 and may be found, with the aid of a good telescope, among the faint stars in the constellation Gemini, about midway between the stars δ and μ (See chart in the February, 1905, number of Popular Astronomy).

Occultations Visible at Washington.

Date. 1905.	Star's Name.	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N pt. °	EMERSION. Washington M.T. h m	EMERSION. Angle from N pt. °	Duration. h m
Dec. 4	27 Piscium	5.1	10 08	66	11 21	243	1 13
4	29 Piscium	5.1	12 25	26	13 10	291	0 45
5	14 Ceti	5.4	3 37	22	4 31	289	0 54
10	δ^1 Tauri	4.2	3 54	112	4 37	218	0 43
10	δ^2 Tauri	3.6	4 11	156	4 18	174	0 08
10	75 Tauri	5.2	4 16	359	4 29	331	0 13
10	Bradley 619	4.8	4 45	85	5 42	242	0 57
10	B. A. C. 1406	6.5	6 18	105	7 14	219	0 56
10	α Tauri	1.1	7 35	101	8 42	221	1 07
11	119 Tauri	4.9	10 52	71	12 22	268	1 30
11	120 Tauri	5.6	11 46	97	13 15	248	1 29
12	DM. +18° 1129	6.2	5 05	121	5 45	223	0 40
14	ζ^1 Cancri	4.6	10 23	89	11 36	277	1 13
14	d^2 Cancri	6.2	19 01	73	19 54	318	0 53
15	π^1 Cancri	6.4	14 21	124	15 44	270	1 23
15	π^2 Cancri	5.6	16 16	85	17 30	316	1 14
16	ν Leonis	5.0	10 07	80	11 03	301	0 56
20	80 Virginis	5.6	12 56	80	13 42	320	0 46
22	γ Librae	4.1	16 15	179	16 35	221	0 20

Satellites of Saturn.

I Mimas. Period $0^d\ 22^h.6$.

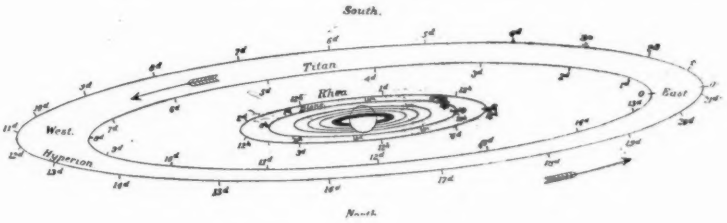
	h		h		h		h		h		
Dec.	5	8.2 E.	Dec.	8	4.1 E.	Dec.	15	5.7 W.	Dec.	23	6.1 E.
	6	6.9 E.		13	8.5 W.		16	4.4 W.		24	4.7 E.
	7	5.5 E.		14	7.1 W.		22	7.5 E.			

II. Enceladus. Period $1^d\ 8.^h9$.

Dec.	1	12.6 E.	Dec.	8	9.1 E.	Dec.	15	5.5 E.	Dec.	22	2.0 E.
	2	21.5 E.		9	17.9 E.		16	14.4 E.		23	10.9 E.
	4	6.4 E.		11	2.8 E.		17	23.3 E.		24	19.7 E.
	5	15.3 E.		12	11.7 E.		19	8.2 E.		26	4.6 E.
	7	0.2 E.		13	20.6 E.		20	17.1 E.		27	13.5 E.

III. Tethys. Period $1^d\ 21.^h3$.

		h			h			h			h
Dec.	1	16.5 E.	Dec.	9	5.7 E.	Dec.	16	19.0 E.	Dec.	24	8.2 E.
	3	13.8 E.		11	3.1 E.		18	16.3 E.		26	5.5 E.
	5	11.1 E.		13	0.4 E.		20	13.6 E.		28	2.8 E.
	7	8.4 E.		14	21.7 E.		22	10.9 E.		30	0.1 E.



IV. Dione. Period $2^d\ 17.^h7$.

Dec.	3	17.0 E.	Dec.	11	22.1 E.	Dec.	20	3.2 E.	Dec.	28	8.3 E.
	6	10.7 E.		14	15.8 E.		22	20.9 E.		31	2.0 E
	9	4.4 E.		17	9.5 E.		25	14.6 E.			

V. Rhea. Period $4^d\ 12.^h5$.

Dec.	3	4.2 E.	Dec.	12	5.2 E.	Dec.	21	6.2 E.	Dec.	30	7.2 E.
	7	16.7 E.		16	17.7 E.		25	18.7 E.			

VI. Titan. Period $15^d\ 23.^h3$.

Dec.	3	2.5 I.	Dec.	10	21.2 S.	Dec.	19	2.2 I.	Dec.	26	21.1 S.
	7	1.0 W.		14	22.4 E.		23	0.8 W.		30	22.5 S.

VII. Hyperion. Period $21^d\ 7.^h6$.

Dec.	3.2 E.	Dec.	9.0 I.	Dec.	14.7 W.	Dec.	19.6 S.

VIII. Iapetus. Period $79^d\ 22.^h1$.

Nov.	8.9 E.	Nov.	29.1 I.	Dec.	19.8 W.	Jan.	18.3 S.

PHENOMENA OF JUPITER'S SATELLITES.

[Central Standard Time.]

The hours after Midnight are numbered 12h, 13h, 14h, etc.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., denotes occulation; Tr., transit of the satellite; Sh., transit of the shadow.

Dec.	1	5 00	I Oc. Dis.	Dec.	8	6 45	I Oc. Dis.
		7 23	I Ec. Re.			9 18	I Ec. Re.
	5	10 00	III Oc. Dis.			5 38	II Ec. Re.
		12 50	III Ec. Re.			6 11	I Tr. Eg.
		13 12	II Oc. Dis.			6 36	I Sh. Eg.
		15 07	I Tr. In.		12	13 17	III Oc. Dis.
		15 26	I Sh. In.			14 52	III Oc. Re.
		16 21	II Ec. Re.			15 13	III Ec. Dis.
	6	12 19	I Oc. Dis.			15 26	II Oc. Dis.
	6	14 49	I Ec. Re.		13	14 04	I Oc. Dis.
	7	7 40	II Tr. In.		14	9 57	II Tr. In.
		8 22	II Sh. In.			11 01	II Sh. In.
		9 33	I Tr. In.			11 17	I Tr. In.
		9 54	I Sh. In.			11 49	I Sh. In.
		10 12	II Tr. Eg.			12 29	II Tr. Eg.
		10 58	II Sh. Eg.			13 30	I Tr. Eg.
		11 45	I Tr. Eg.			13 37	II Sh. Eg.
		12 07	I Sh. Eg.			14 02	I Sh. Eg.

Phenomena of Jupiter's Satellites.—Continued.

Dec.15	8	30	I Oc. Dis.	Dec.21	8	13	I Sh. In.
	11	14	I Ec. Re.		9	16	III Sh. In.
16	4	34	II Oc. Dis.		9	41	I Tr. Eg.
	4	42	III Tr. Eg	23	10	25	I Sh. Eg.
	5	16	III Sh. In.		10	49	II Ec. Re.
	5	43	I Tr. In.		11	11	III Sh. Eg.
	6	18	I Sh. In.	24	4	42	I Oc. Dis.
	7	09	III Sh. Eg.		7	38	I Ec. Re.
	7	56	I Tr. Eg.	25	4	54	I Sh. Eg.
	8	14	II Ec. Re.		5	34	II Sh. Eg.
	8	31	I Sh. Eg.	28	14	35	II Tr. In.
17	5	42	I Ec. Re.		14	48	I Tr. In.
21	12	15	II Tr. In.		15	39	I Sh. In.
	13	02	I Tr. In	29	12	02	I Oc. Dis.
	13	39	II Sh. In.		15	05	I Ec. Re.
	13	44	I Sh. In	30	9	09	II Oc. Dis.
	14	48	II Tr. Eg.		9	15	I Tr. In.
	15	15	I Tr. Eg.		9	50	III Tr. In.
	15	57	I Sh. Eg.		10	07	I Sh. In.
	16	15	II Sh. Eg.		11	28	I Tr. Eg.
22	10	16	I Oc. Dis.		11	34	III Tr. Eg.
	13	09	I Ec. Re.		12	20	I Sh. Eg.
23	6	26	III Tr. In.		13	17	III Sh. In.
	6	50	II Oc. Dis.		13	25	II Ec. Re.
	7	29	I Tr. In.	31	6	29	I Oc. Dis.
	8	06	III Tr. Eg.		9	34	I Ec. Re.

VARIABLE STARS.

Twenty-two New Variable Stars 80-101.1905 Lyræ.— In *A. N.* 4046 Messrs. M. and G. Wolf announce twenty-two new variables discovered in the vicinity of γ Lyrae. These were discovered by comparison of 14 photographs taken at Königstuhl in the years 1896, 1901, 1903, 1904 and 1905. Six variables were previously known in this same region. All are faint stars, the brightest attaining only the magnitude 9.5 at maximum. Twenty four photographic charts are given showing the faint stars in the immediate vicinity of each variable. The following table gives the position for 1900 and the range of the observed brightness of the variables:

Designation	R. A. 1900 h m s	Decl. 1900 ° ′ ″	Mag.
RY	18 41 15.22	+ 34 34 16.8	9.5 — <13
80.1905	42 01.09	+ 36 11 39.3	10.5 — 13.5
59.1905	50 06.76	+ 36 23 06.2	10 — <15
RX	50 26.68	+ 32 42 16.6	11 — <13.5
81.1905	51 08.43	+ 29 43 31.4	11 — <13
82.1905	51 09.46	+ 31 19 43.4	11.5 — <13
83.1905	51 31.28	+ 34 53 36.4	12.5 — 14
84.1905	51 39.99	+ 32 46 44.1	12.5 — 15
85.1905	52 02.56	+ 33 26 12.3	12.5 — 13.5
86.1905	53 02.10	+ 31 24 29.8	13 — <15
Z	55 59.47	+ 34 48 54.9	10.5 — 14
87.1905	58 28.59	+ 30 52 04.8	12 — 13
88.1905	18 48 40.50*	+ 31 46 52.9	13 — <15
89.1905	19 01 35.44	+ 34 07 36.2	12.5 — <15
90.1905	01 46.48	+ 29 28 53.2	12.5 — 14
91.1905	02 03.59	+ 31 04 43.1	12.5 — 14.5
92.1905	02 36.35	+ 31 27 14.9	12 — <15
93.1905	03 18.58	+ 33 34 09.1	11 — 13.5
94.1905	03 55.26	+ 34 40 35.3	11 — 14

Designation	R. A. 1900	Decl. 1900	Mag.
Z	h m s	° ′ ″	
95.1905	19 03 59.28	+ 30 35 50.0	10.5 — 12
96.1905	04 39.75	+ 30 33 50.5	12 — <15
97.1905	04 49.19	+ 31 05 35.0	10.5 — 12
V	05 09.53	+ 29 29 52.4	10.5 — <15
98.1905	05 22.91	+ 29 23 19.2	11 — 12.5
99.1995	07 39.67	+ 36 00 37.7	12 — <14
100.1905	08 28.03	+ 34 22 10.3	12 — 13.5
RS	09 17.83	+ 33 14 33.3	11.5 — <13.5
101.1905	19 09 51.78	+ 33 19 12.9	11 — <13

* Out of correct order in R. A.

New Algol Variable 102.1905 Tauri.—This was discovered by Mrs. Fleming on the photographs taken at Harvard College Observatory. The star, when at normal brightness, has the photographic magnitude 7.14 and is brighter than the adjacent double star DM + 27°618, magnitude 7.5. At intervals of 2.77 days its light is reduced to the eleventh magnitude, giving it a range of nearly four magnitudes, which is much greater than that of any other Algol type variable as yet discovered. It has been found upon 572 photographs taken at Harvard Observatory from Nov. 11, 1885 to April 6, 1905. The elements given by Professor Pickering in Circular No. 104 are

Minimum = J. D. 2410002.16 + 2.76886 E.

The position of this variable for 1900.0 is

R. A. = $3^h\ 57^m\ 45^s.27$ Decl. = + 27° 50′ 59″.7.

New Variable 103.1905 Ophiuchi.—This is announced in *A. N.* 4046 as discovered by Mme L. Ceraski on the Moscow photographs. Its position for 1900 is

R. A. = $18^h\ 40^m\ 55^s.8$ Decl. = + 7° 06′.4

On ten photographs taken in 1899 and 1900 it was of the same brightness, about 9.3 magnitude, but upon one taken July 24, 1900 it was decidedly fainter, about 10½ magnitude. M. Blajko has observed it visually this year and found it to be of 9.2 magnitude on May 19, 29, 31, June 19, 20, 21, 23 and 24, while on July 28, 29, August 1, 2, 4 and 5 it was of 10.3 magnitude. On August 6, it was 10.2 and on August 7, 9.4 magnitude.

Nova 104.1905 Aquilæ.—August 31, Mrs. Fleming in examining the photographs taken at Harvard College Observatory discovered a new star in the constellation Aquilae. A plate exposed for 75 minutes on August 18 showed a ninth magnitude star where on August 10 and on earlier dates as far back as 1888, plates with longer exposure show no star. On August 21 it had decreased to 9.3 and on August 26 to 10.0 magnitude, while on the date of its discovery it had faded to 10.3. The waning of its light has continued and on September 22 it was down to 11.2 magnitude. The spectrum, which was photographed upon the discovery plate on August 18, very closely resembles that of Nova Persei No. 2 on March 30, 1901, showing the lines Hδ, Hγ, 4272, 4646 and Hβ very broad and bright. The lines Hγ and Hβ have accompanying dark lines on the edge of shorter wave length. The position of the star for 1855 is

R. A. = $18^h\ 54^m\ 25^s.1$ Decl. = — 4° 38′.6.

This being the second new star discovered in the constellation Aquila, should be designated as Nova Aquilæ No. 2. Nova Aquila No. 1 was first photographed

on April 21, 1899 and was discovered in the same way as No. 2, i. e. by means of its peculiar spectrum.

New Variable 105.1905 Camelopardalis.—This is the star B. D. + 79°.286 magnitude 8.3 and its variability was discovered by Mme L. Ceraski on the Moscow photographs. From 26 photographs taken in 1897-1905 the brightness of the star appears to vary between 8.4 and 9.2 magnitude. The period seems to be short but the data are insufficient to determine it. The position of the star for 1900 is

R. A. = $8^h\ 36^m\ 55^s.97$ Decl. = + 79° 19′ 39″.2.

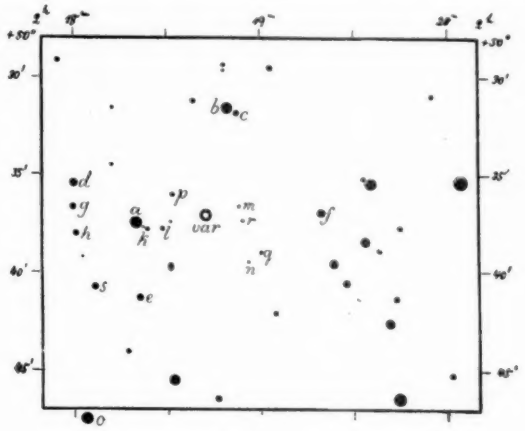
Variable Star Observations at Hamburg.—A very valuable pamphlet to variable star observers has just come to hand in "Mitteilungen der Hamburger Sternwarte No. 8". It contains the observations of 27 variable stars made by Mr. K. Graff, with the 9-inch equatorial at the Hamburg Observatory during the years 1902-1905. The author, after a brief introduction explaining his methods of observation and reduction, gives for each star: its position for 1855.0; references to the literature concerning the star; a list of comparison stars; his own observations in detail; a determination of the elements where possible; and finally a comparison of the observed maxima and minima by all observers with his elements. For eight of these variables he gives very excellent charts showing the positions and relative brightness of the neighboring stars. In sending to Popular Astronomy a copy of the pamphlet the author very kindly enclosed the original copies of the charts, so that we are enabled to reproduce them at first hand for the benefit of our readers. There are also at the end of the pamphlet charts of the light-curves of 16 of the 27 variables. These charts we shall reproduce later as we may have room for them.

The following table gives in briefest form the result of Mr. Graff's investigations:

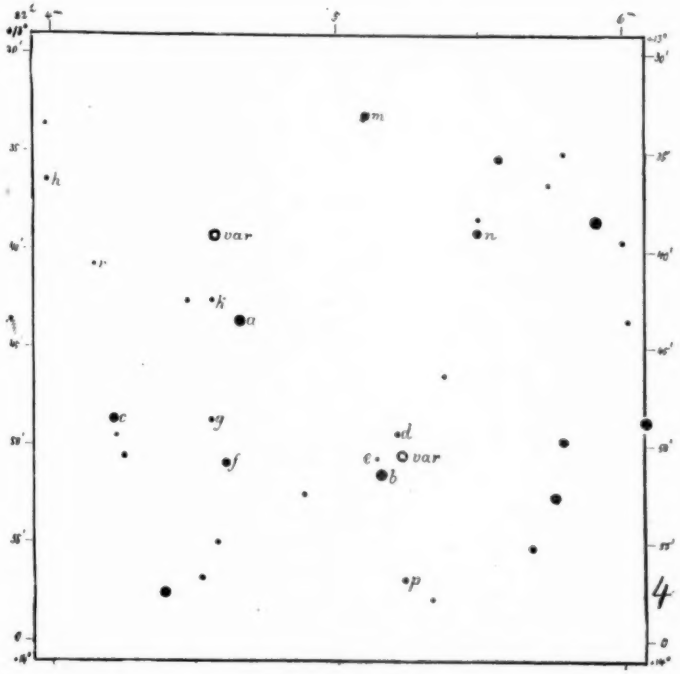
ELEMENTS OF VARIABLE STARS.

Determined by Mr. K. Graff, Hamburg Observatory.

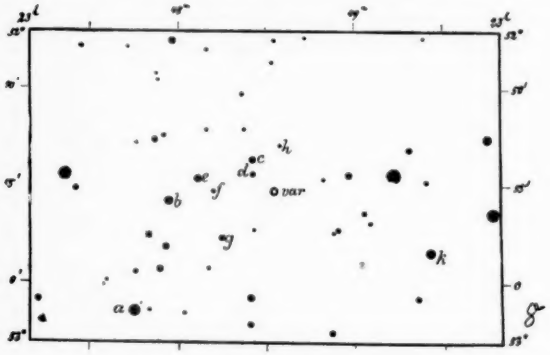
Variable	Elements, Greenwich M. T. M = Maximum m = minimum (d)	M—m	Magnitude M (m m)	Magnitude m (m m)	Color*
Z Aurig.	M = 241624 + 112.8 E	53	9.3—9.5	10.0—10.4	5
Z Gem.	— —	—	9.5:	11.8	—
UU Cyg.	— —	—	9.2::	—	2
U Lacer.	— —	—	7.4:	9.5:	6.3
X Andr.	M = 2415062 + 342. E	190:	8.8—9.2	<12.8	5.3
RR Andr.	M = 2415833 + 328 E	174	8.8—9.2	12.3.0^d<	4.0
RR Pers.	M = 2399331 + 372.6 E	180:	8.9	<12'8	7.4
Y Pers.	M = 2415741 + 253.6 E	127	8—9	9.5—10.2	7.1
RU Virg.	M = 2413314 + 440 E	156:	8.4	<11	8.2
W Coro.	M = 2410106 + 238 E[1]	115	7.8—8.5	<12.2	4.0
RT Aqu.	M = 2411546 + 329.5 E	128	8—9	12	6.5
T Peg.	M = 2402155 + 373.8 E[2]	—	8.4—9.5	<11	4.2
RS Peg.	M = 2416279 + 436 E	—	8.8—9.5	<12.5	—
V Ur. Mj.	m = 2416233 + 202. E	—	9.5	10.7	2:
RT Ophi.	M = 2415347 + 426 E	—	10	<12.5	3:
RY Herc.	M = 2415080 + 222.3 E	100	8.5	<12.8	2.5
RX Lyr.	M = 2413751 + 247.7 E	—	11	<14	2:
RT Lyr.	M = 2415698 + 249.3 E	—	9—10	<12.8	3.2
Z Delph.	M = 2398539 + 303.4 E	—	8.7	<12.0	2.7
Y Delph.	M = 2416480 + 487 E	—	9—10	<12.5	2:
RT Peg.	M = 2416082 + 214.6 E	—	10	<12.5	1:
Y Peg.	M = 2415324 + 203.3 E	—	9.7	<12.5	2.2



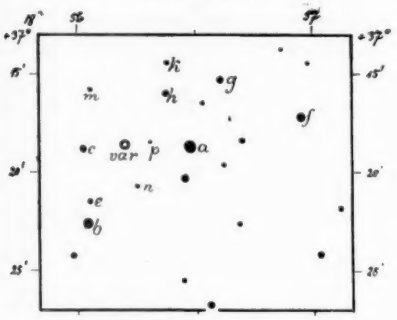
RR PERSEI



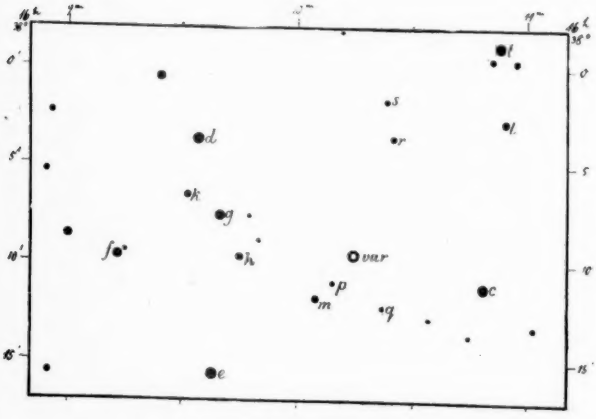
RS AND Y PEGASI



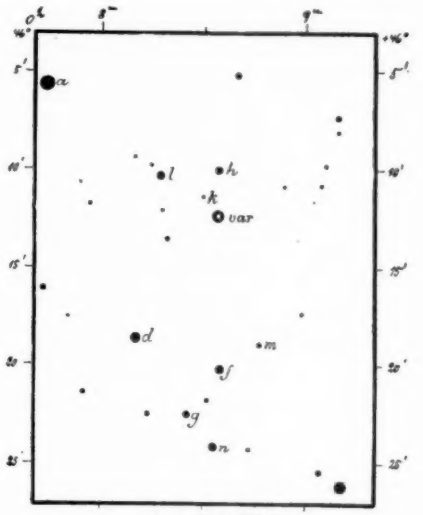
RR CASSIOP.



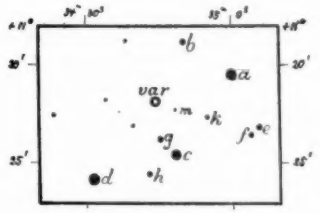
RT LYRÆ



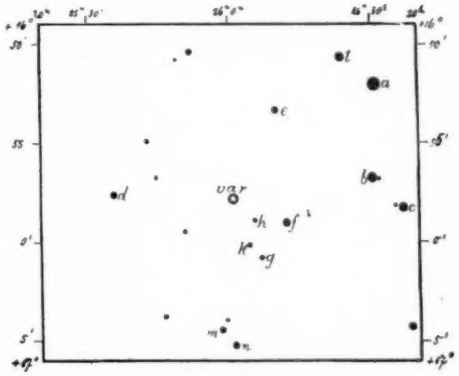
W CORONÆ



X ANDROMEDA



W DELPHINI



Z DELPHINI

ELEMENTS OF VARIABLE STARS.—Continued.

		M—m	Magnitude M	Magnitude m	Color*
	d d		m m	m m	
RR Cass.	M = 2415345 + 307 E	158:	9.6	<12.8	1.4
RT Pers.	m = 2416741.d24514 + 0.d84943 E	0.0757	9.46	10.5	2
U Sagit.	m = 2415690. 269 + 3. 380674 E [3]	—	6.7	8.7:	0:
W Delph.	m = 2413564. 571 + 4. 8064 E [4]	0.29	9.3	11.2	3:
RR Gem.	M = 2416223.d372 + 0. 397238 E				

[1]) According to Pickering (A. N. 161.265). [2]) According to Chandler (A. J. 24.7).
[3]) According to Ebell (A. N. 158.31). [4]) According to Pickering (A. J. 16.159).
* Osthoff's Scale.

Of the 27 stars three, RT Persei, U Sagittæ, and W Delphini are of the Algol type; one, RR Geminorum, is of the ant-Algol or δ Cephei type: three, Z Geminorum, UU Cygni and U Lacertæ are of uncertain type or irregular in variation. The others are of long period and several of them of the Mira type.

The following are the positions for 1855.0:

	No.	Variable.	R. A. h	m	s	Decl. °	′	type
1	1.1903	Z Aurigæ	5	50	00	+ 53	17.4	Mira type.
2	9.1903	Z Geminorum	6	58	53	+ 22	44.9	Uncertain.
3	38.1901	UU Cygni	21	33	53	+ 42	32.7	Uncertain.
4	2.1902	U Lacertae	22	41	47	+ 54	23.7	Irregular.
5	3.1900	X Andromedæ	0	08	33	+ 46	12.4	Mira type.
6	69.1901	RR Andromedæ	0	43	31	+ 33	35.2	Mira type.
7	1.1904	RR Persei	2	18	43	+ 50	37.1	Mira type.
8	68.1901	Y Persei	3	17	52	+ 43	39.9	Mira type.
9		RU Virginis	12	39	56	+ 4	56.3	Mira type.
10	18.1902	W Coronæ	16	10	14	+ 38	09.6	Mira type.
11		RT Aquilæ	19	31	12	+ 11	23.8	Mira type.
12		T Pegasi	22	01	49	+ 11	49.9	Mira type.
13	12.1902	RS Pegasi	22	05	13	+ 13	50.9	Mira type.
14	70.1901	V Ursae Majoris	8	57	58	+ 51	41.5	Uncertain.
15	76.1901	RT Ophiuchi	17	49	45	+ 11	11.5	
16		RY Herculis	17	53	28	+ 19	29.7	
17	10.1903	RX Lyræ	18	48	46	+ 32	39.0	
18	5.1902	RT Lyræ .	18	56	13	+ 37	19.1	
19	16.1902	Z Delphini	20	26	01	+ 16	57.7	
20	15.1902	Y Delphini	20	34	44	+ 11	21.8	
21	19.1902	RT Pegasi	21	57	51	+ 34	25.3	
22	19.1900	Y Pegasi	22	04	35	+ 13	39.2	
23	5.1900	RR Cassiopeiæ	23	48	32	+ 52	55.1	
24	155.1904	RT Persei	3	13	39	+ 46	02.3	Algol type.
25	93.1901	U Sagittæ	19	12	28	+ 19	20.9	Algol type.
26		W Delphini	20	31	04	+ 17	46.6	Algol type.
27	13.1903	RR Geminorum	7	12	18	+ 31	09.0	δ Cephei type.

Maxima of UY Cygni.

Period 13h 27m 27s.59

		h		h		h		h
Dec.	1	16	Dec. 9	12	Dec. 17	9	Dec. 25	5
	2	19	10	15	18	11	26	8
	3	22	11	18	19	14	27	11
	5	0	12	21	20	17	28	14
	6	3	14	0	21	20	29	17
	7	6	15	3	22	23	30	20
	8	9	16	6	24	2		

Approximate Magnitudes of Variable Stars on Sept. 10, 1905.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
T Androm.	0	17.2	+26	26	8.0 *i*	R Camelop.	14	25.1	+84	17	13.3
T Cassiop.	0	17.8	+55	14	12.0	R Bootis	14	32.8	+27	10	11.7*d*
R Androm.	0	18.8	+38	1	13.2*d*	S Librae	15	15.6	−20	2	*s*
S Ceti	0	19.0	− 9	53	12.0*d*	S Serpentis	15	17.0	+14	40	10.9*d*
S Cassiop.	1	12.3	+72	5	13.0*d*	S Coronae	15	17.3	+31	44	12.8*d*
R Piscium	1	25.5	+ 2	22	11.5*d*	S Urs. Min.	15	33.4	+78	58	8.0 *i*
U Persei	1	52.9	+54	20	9.0*d*	R Coronae	15	44.4	+28	28	5.9 *i*
R Arietis	2	10.4	+24	36	12.5	V "	15	45.9	+39	52	11.7*d*
o Ceti	2	14.3	− 3	26	9.5	R Serpentis	15	46.1	+15	26	9.8*d*
S Persei	2	15.7	+58	8	9.5	R Herculis	16	1.7	+18	38	11.0*d*
R Ceti	2	20.9	− 0	38	*f*	R Scorpii	16	11.7	−22	42	<16
U "	2	28.9	−13	35	11.3*d*	S "	16	11.7	−22	39	10.5
R Trianguli	2	31.0	+33	50	11.5 *i*	U Herculis	16	21.4	+19	7	12 *d*
R Persei	3	23.7	+35	20	*f*	W Herculis	16	31.7	+38	32	9.8*d*
R Tauri	4	22.8	+ 9	56	*u*	R Draconis	16	32.4	+66	58	11.5*d*
S "	4	23.7	+ 9	44	*u*	S Herculis	16	47.4	+15	7	11.5*d*
R Aurigæ	5	9.2	+53	28	10.7*d*	R Ophiuchi	17	2.0	−15	58	12.0*d*
U Orionis	5	49.9	+20	10	9.8*d*	T Herculis	18	5.3	+31	0	9.4*d*
R Lyncis	6	53.0	+55	28	9.5 *i*	R Scuti	18	42.2	− 5	49	5.5
R Gemin.	7	1.3	+22	52	*u*	R Aquilae	19	1.6	+ 8	5	11.5*d*
S Canis Min.	7	27.3	+ 8	32	*u*	R Sagittarii	19	10.8	−19	59	9.3*d*
R Cancri	8	11.0	+12	2	*u*	S "	19	13.6	−19	12	*u*
V "	8	16.0	+17	36	*u*	R Cygni	19	14.1	+49	58	14.0
S Hydrae	8	48.4	+ 3	27	*u*	RT "	19	40.8	+48	32	11.0*d*
T "	8	50.8	− 8	46	*u*	X "	19	46.7	+32	40	11 *i*
R Leo. Min.	9	39.6	+34	58	*u*	S "	20	3.4	+57	42	14.8
R Leonis	9	42.2	+11	54	*u*	RS "	20	9.8	+38	28	8
R Urs. Maj.	10	37.6	+69	18	12.2*d*	R Delphini	20	10.1	+ 8	47	13.2*d*
R Comae Ber.	11	59.1	+19	20	10.5*d*	U Cygni	20	16.5	+47	35	7 *i*
T Virginis	12	9.5	− 5	29	*s*	V "	20	38.1	+47	47	13.5*d*
R Corvi	12	14.4	−18	42	*s*	T Aquarii	20	44.7	− 5	31	8.2*d*
Y Virginis	12	28.7	− 3	52	*s*	R Vulpec.	20	59.9	+23	26	11.7*d*
T Urs. Maj.	12	31.8	+60	2	11 *i*	T Cephei	21	8.2	+68	5	10.0*d*
R Virginis	12	33.4	+ 7	32	*s*	S "	21	36.5	+78	10	10.3d
S Urs. Maj.	12	39.6	+61	38	8.4*d*	S Lacertae	22	24.6	+39	48	8.0 *i*
U Virginis	12	46.0	+ 6	6	*s*	R "	22	38.8	+41	51	14.7*d*
V "	13	22.6	− 2	39	*s*	S Aquarii	22	51.8	−20	53	14.2
R Hydrae	13	24.2	−22	46	*s*	R Pegasi	23	1.6	+10	0	9.0*d*
S Virginis	13	27.8	− 6	41	*s*	S "	23	15.5	+ 8	22	8.6 *i*
R Can. Ven.	13	44.6	+40	2	11.5*d*	R Aquarii	23	38.6	+15	50	10.5
S Bootis	14	19.5	+54	16	13.7*d*	R Cassiop.	23	53.3	+50	50	12.0*d*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that the light is increasing; *d*, that the light is decreasing; *s*, that it is near the Sun; and *u*, that its magnitude is unknown.

From observations made at the McCormick, Vassar College, Whiteside and Harvard Observatories.

Maxima of RZ Lyræ.

	h		h		h		h
Dec. 1	18	Dec. 8	22	Dec. 16	2	Dec. 23	6
2	19	9	23	17	3	24	7
3	20	10	23	18	3	25	7
4	20	12	0	19	4	26	8
5	21	13	1	20	4	27	8
6	21	14	1	21	5	29	9
7	22	15	2	22	5	30	9
						31	10

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.	
	d	h	d	h
R Crucis	Dec. 1	4	Dec. 2	13
W Geminorum	1	5	3	20
SU Cygni	2	0	3	8
U Vulpeculae	2	17	4	20
S Crucis	2	18	4	6
R Triang. Austr.	3	3	4	3
V Centauri	3	4	4	15
T Velorum	3	6	4	15
S Triang. Austr.	3	19	5	21
V Velorum	4	6	5	5
T Vulpeculae	4	9	5	18
δ Cephei	4	9	5	18
ζ Geminorum	4	19	9	19
SU Cygni	5	20	7	4
TX Cygni	5	20	10	23
VY Cygni	5	23	8	1
η Aquilae	6	3	8	12
R Triang. Austr.	6	13	7	13
R Crucis	7	0	8	9
V Carinae	7	3	9	7
S Sagittae	7	5	10	15
T Crucis	7	7	9	8
S Crucis	7	11	8	23
T Velorum	7	21	9	6
V Centauri	8	16	10	3
V Velorum	8	15	9	14
T Vulpeculae	8	19	10	4
S Muscae	8	22	12	9
W Geminorum	8	23	11	14
T Minocerotis	9	3	17	1
SU Cygni	9	16	11	0
δ Cephei	9	18	11	3
R Triang Austr.	9	22	10	22
S Triang. Austr.	10	3	12	5
W Virginis	10	13	18	17
U Vulpeculae	10	16	12	19
S Crucis	12	4	13	16
T Velorum	12	13	13	22
R Crucis	12	20	14	5
V Velorum	13	0	13	23
η Aquilae	13	7	15	16
R Triang. Austr.	13	8	14	8
T Vulpeculae	13	10	14	19
SU Cygni	13	13	14	21
V Carinae	13	19	15	23
VY Cygni	13	19	15	21
T Crucis	14	0	16	1
V Centauri	14	4	15	15
ζ Geminorum	14	23	19	23
δ Cephei	15	2	16	11
S Sagittae	15	14	19	0
S Triang. Austr.	16	11	18	13
R Triang. Austr.	16	17	17	17
W Geminorum	16	17	19	8
S Crucis	Dec. 16	21	Dec. 18	9
T Velorum	17	4	18	13
X Cygni	17	8	22	11
V Velorum	17	9	18	8
SU Cygni	17	9	18	17
T Vulpeculæ	17	16	19	1
S Muscae	18	13	22	0
R Crucis	18	16	20	1
U Vulpeculae	18	16	20	19
V Centauri	19	16	21	3
R Triang. Austr.	20	2	21	2
δ Cephei	20	11	21	20
η Aquilae	20	11	22	20
V Carinae	20	13	22	17
TX Cygni	20	13	25	16
T Crucis	20	18	22	19
SU Cygni	21	5	22	13
S Crucis	21	14	23	2
V Y Cygni	21	15	23	17
V Velorum	21	18	22	17
T Velorum	21	19	23	4
T Vulpeculae	22	3	23	12
S Triang. Austr.	22	19	24	21
R Triang. Austr.	23	11	24	11
S Sagittae	23	23	27	9
W Geminorum	24	11	27	2
R Crucis	24	12	25	21
SU Cygni	25	1	26	9
ζ Geminorum	25	3	30	3
V Centauri	25	4	26	15
δ Cephei	25	20	27	5
V Velorum	26	3	27	2
S Crucis	26	6	27	18
T Velorum	26	10	27	19
T Vulpeculae	26	13	27	22
U Vulpeculae	26	15	28	18
R Triang. Austr.	26	21	27	21
V Carinae	27	5	29	9
T Crucis	27	11	29	12
η Aquilae	27	16	30	1
W Virginis	27	19	35	23
S Muscae	28	4	31	15
S U Cygni	28	22	30	6
S Triang. Austr.	29	3	31	5
VY Cygni	29	12	31	14
R Triang. Austr.	30	6	31	6
R Crucis	30	8	31	17
V Velorum	30	12	31	11
V Centauri	30	15	32	2
S Crucis	30	23	32	11
T Vulpeculae	31	0	32	9
T Velorum	31	2	32	11
δ Cephei	31	5	32	14

Maxima of Y Lyræ.

Period $12^h\ 03^m.9$

	h		h		h		h
Dec. 1-4	8	Dec. 5-12	9	Dec. 13-19	10	Dec. 20-27	11
						28-31	12

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

U Cephei.

	d	h
Dec.	1	7
	3	18
	6	6
	8	18
	11	6
	13	18
	16	6
	18	17
	21	5
	23	17
	26	5
	28	17
	31	5

Z Persei.

	d	h
Dec.	3	10
	6	12
	9	13
	12	15
	15	16
	18	17
	21	19
	24	20
	27	21
	30	23

Algol.

	d	h
Dec.	3	11
	6	7
	9	4
	12	1
	14	22
	17	19
	20	16
	23	12
	26	9
	29	6

RT Persei

	d	h
Dec.	1	6
	2	2
	2	23
	3	19
	4	15
	5	12
	6	8
	7	5
	8	1
	8	21
	9	18
	10	14
	11	11
	12	3
	14	0
	14	20
	15	16
	16	13
	17	9

RT Persei

	d	h
	18	6
	19	2
	19	22
	20	19
	21	15
	22	12
	23	8
	24	4
	25	1
	25	21
	26	18
	27	14
	28	10
	29	7
	30	3
	30	23
	31	20

λ Tauri.

	d	h
Dec.	2	6
	6	5
	10	4
	14	2
	18	1
	22	0
	25	23
	29	22

R Canis Maj.

	d	h
Dec.	1	7
	2	10
	3	13
	4	16
	5	20
	6	23
	8	2
	9	6
	10	9
	11	12
	12	15
	13	19
	14	22
	16	1
	17	4
	18	8
	19	11
	20	14
	21	17
	22	21
	24	0
	25	3
	26	6
	27	10
	28	13
	29	16
	30	20
	31	23

Y Camelop.

	d	h
Dec.	2	9
	5	17
	9	0
	12	7
	15	15
	18	22
	22	5
	25	13
	28	20

RR Puppis

	d	h
Dec.	2	8
	8	18
	15	5
	21	15
	28	1

V Puppis.

	d	h
Dec.	1	3
	2	14
	4	0
	5	11
	6	22
	8	9
	9	20
	11	7
	12	18
	14	5
	15	16
	17	3
	18	14
	20	0
	21	11
	22	22
	24	9
	25	20
	27	7
	28	18
	30	5
	31	16

S Cancri.

	d	h
Dec.	1	8
	10	19
	20	7
	29	19

S Antliæ.

Period $7^h\ 46^m.8$

	d	h
Dec.	1	19
	2	18
	3	17
	4	17
	5	16
	6	15
	7	15
	8	14
	9	13
	10	13

S Antliæ

	d	h
	11	12
	12	11
	13	11
	14	10
	15	10
	16	9
	17	8
	18	8
	19	7
	20	6
	21	6
	22	5
	23	4
	24	4
	25	3
	26	2
	27	2
	28	1
	29	0
	30	0
	30	23
	31	22

S Velorum.

	d	h
Dec.	6	22
	12	20
	18	19
	24	17
	30	15

W Urs. Maj.

Period $4^h\ 0^m\ 13.2_s$

Dec. 1-31 20^h

RR Velorum

	d	h
Dec.	1	22
	3	18
	5	15
	7	11
	9	8
	11	4
	13	1
	14	21
	16	18
	18	14
	20	11
	22	7
	24	4
	26	0
	27	21
	29	17
	31	14

Z Draconis.

	d	h
Dec.	1	22
	3	6
	4	15
	5	23
	7	8
	8	17

Z Draconis.

	d	h
	10	1
	11	10
	12	18
	14	3
	15	12
	16	20
	18	5
	19	13
	20	22
	22	6
	23	15
	25	0
	26	8
	27	17
	29	1
	30	10
	31	18

δ Libræ

	d	h
Dec.	2	22
	5	6
	7	14
	9	22
	12	6
	14	13
	16	21
	19	5
	21	13
	23	21
	26	5
	28	13
	30	20

U Coronæ

	d	h
Dec.	2	22
	6	9
	9	20
	13	7
	16	18
	20	4
	23	15
	27	2
	30	13

RV Lyræ.

	d	h
Dec.	4	3
	7	17
	11	8
	14	22
	18	12
	22	3
	25	17
	29	7

U Sagittæ.

	d	h
Dec.	1	4
	4	13
	7	22
	11	7
	14	16
	18	1

Minima of Variable Stars of the Algol Type.—Continued.

U Sagittæ.		SW Cygni.		UW Cygni.		Y Cygni.		VV Cygni.	
	d h		d h		d h		d h		d h
Dec.	21 10	Dec.	3 6	Dec.	18 15	Dec.	11 10	Dec.	9 8
	24 20		7 20		22 2		13 0		10 20
	28 5		12 9		25 13		14 9		12 7
	31 14		16 23		29 0		16 0		13 18
SY Cygni.			21 13	W Delphini.			17 9		15 6
Dec.	5 8		26 3	Dec.	3 14		19 0		16 17
	11 8		30 16		8 9		20 9		18 5
	17 8	VW Cygni.			13 4		22 0		19 16
	23 9	Dec.	3 10		18 1		23 9		21 4
	29 9		11 21		22 19		25 0		22 15
WW Cygni.			20 7		27 15		26 9		24 3
Dec.	3 17		28 17	Y Cygni.			28 0		25 14
	7 1			Dec.	1 1		29 9		27 2
	10 9	UW Cygni.			2 10		31 0		28 13
	13 16	Dec.	1 9		4 1	VV Cygni.			30 0
	17 0		4 20		5 10	Dec.	1 23		31 12
	20 8		8 7		7 0		3 10	UZ Cygni.	
	23 16		11 18		8 10		4 42	Dec.	3 16
	26 23		15 4		10 0		6 9		
	30 6						7 21		

GENERAL NOTES.

Professor Samuel J. Buck's Forty Years of Service at Iowa College at Grinnell. At the commencement in June Samuel J. Buck, Professor of Mathematics and Astronomy, retired from active service and was made Professor Emeritus after a continuous service of forty one years at Iowa College. He graduated at Oberlin College in 1858. In 1862, he graduated from Oberlin, Theological Seminary, entered the University in 1864, was made Principal of the Academy in Iowa College, 1864, elected Professor of Mathematics and Physics in Iowa College, 1869, made Professor of Mathematics and Astronomy, at same College, in 1893 which position he has held until the present time.

July fourth 1905 Professor Buck was 70 years old; he is in excellent health, and he leaves the honored position which he has made and brought to high college rank after more than two scores of years of faithful service in Christian loyalty to Iowa College, that was appreciated in marked way by the friends of the College at the time of his retirement. His is a noble record that will stand for high reward.

Washington Reduction Tables.—A neat volume of quarto size, appendix III, Vol. IV of the second series of the Washington publications is at hand. It discusses differential refraction and the instrumental constants with extended tables for the same, and for instrumental corrections. The volume is published under the direction of Rear-Admiral Colby M. Chester, U. S. N.

Professor Carr W. Pritchett, through whose efforts the Pritchett College and Morrison Observatory, Glasgow, Mo., were founded and by whose zeal have been fostered, gives up his active life at the age of 83.

Those who have known Professor Pritchett realize that, since its foundation the Observatory has been the center of his interest and work.

The Clark 12¼-inch equatorial was mounted in 1875, and the 6-inch meridian

circle in 1877. Without assistance one man could not use both instruments and the latter has been used only for the determination of time and the position of the observatory.

The work of the equatorial has been such as usually pertains there to. No provision has been made to remove the original defect of not being able to set the circles from the eye end, the only declination circle being on the opposite end of its axis from the tube.

Professor Pritchett has improved the observatory equipment in many ways and leaves to the astronomical world the rich legacy of Miss Morrison enhanced by the fruits of his own energies.

Dr. Herbert R. Morgan, the successor to this directorship, hails from the U. S. Naval Observatory, and asks us to solicit the continued interest of scientists in the Observatory, and their support in contributing to its library which lacks the books even to begin a line of work.

William Bond & Son's Chronometers. We have used the electric break circuit chronometer No. 374 by William Bond & Son for twenty eight years, and it has done excellent service for nearly all that long period of time. It has been used in several expeditions for mountain and solar eclipse work at distances from 1000 to 2000 miles from Goodsell Observatory with entire satisfaction of the parties using it. We can unhesitatingly recommend chronometers of this make.

Dr. Walter F. Wislicenus, Editor in Chief of the Astronomische Jahresbericht, died October 3. He was born November 5, 1859: was a member of the German Transit of Venus expedition of 1882: assistant in the Observatory of the University of Strassburg 1883-89: instructor in the University since 1887 and Professor since 1894. Since 1899 he has edited six volumes of the Astronomische Jahresbericht, aggregating 3764 octavo pages embracing reviews of 13, 874 separate books and articles.

The Solar Eclipse in Scotland.—In Scotland the observation of the partial eclipse on August 30 was more or less hampered by clouds. In Edinburgh very little was seen of the phenomenon. At Balerno ten miles from Edinburgh, however, the end of the eclipse was well observed. The morning and forenoon were most unpromising and nothing was seen of the first contact. The greatest phase was observed through a break in the clouds at one o'clock, three fourths of the Sun's disc being obscured. At 1:30 the clouds dispersed and the end of the eclipse was well observed. Several drawings were made and observations taken on the passage of the Moon's disc over the spots visible on the Sun. The eclipse was observed with a two-inch refractor.

Hector Macpherson Jr.

Johnsburn, Balerno, Scotland, Sept. 4.

The Total Solar Eclipse,* observed by Marcel Moye, of the University. I observed this magnificent eclipse at Alcala de Chisvert, a little town on the east coast of Spain. I venture to say, I was favored by the Spanish skies. The

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* See Frontispiece.

day before, we had dull and wet weather, with some rain. Hope was almost gone, but at night, the clouds broke away and stars were glittering everywhere. At sunrise, however, an ominous bank of clouds was hanging towards the south and all the morning, we watched the clouds on the horizon,—a rather painful watch.

The first contact was seen in a perfectly clear sky, but some minutes after, two or three cumuli went from W. and slowly made their way before the Sun. I was again in despair, but at the eventful moment, the clouds were far and totality displayed its beauties without interference, except at the end, a light and transparent vapor of which I shall say a word later.

In order to secure good observations, my program was very limited and I had plenty of time to fill it without hurry. I restricted myself to the observation of: the Shadow Bands;) (2) the Corona; (3) the General Aspects of the eclipse.

The Shadow Bands. In 1900 at Elche, I had had a good view of this phenomenon and I was eager to see again these enigmatic bands. I saw them three minutes before and three minutes after totality, being unable to catch any during the total phase. They were grayish ribbons, not black, tolerably distinct and very wavy. I noticed their direction from S. W. to N. E., and a perpendicular motion from N. W. to S. E., both before and after totality. The wind, moderate, was blowing from S. W. and clouds drifted from W. or N. W.

On the soil, white and smooth (the platform of the station), I had some rods with metric gradations; I estimated the width of the bands at two inches and their distance apart at three or four inches. The motion was slow, difficult to observe exactly, perhaps one or two inches per second. The Shadow-Bands were suggestive of a rope tied by an end and made to wave by the hand at the other end.

The Corona. For observation of the Corona, I used only a good opera glass. I sketched carefully the coronal streamers and I had time enough to compare my drawing with the actual Sun. The Sun was encircled by a white silver ring, very bright, almost dazzling at the limb, but fading away softly in the darkness of the sky. Around this inner corona, was an intricate system of streamers, of a pearly hue, and looking on the whole, like an irregular star with six or seven points. Long rays were diverging from the solar poles, a perfect contrast with the equatorial wings of the 1900 eclipses. Even to the naked eye, two groups of prominences were evident, magnificent rosy flames on the white corona. The brightest group was at N. E., the other one at S. E., almost diametrically opposite.

All the coronal streamers were more or less of an ogival form, or "angel's wing" as noticed in previous eclipses. Their bases were broad and they were tapering and melting away very gradually. Three of the streamers are worthy of special notice.

The N. E. ray was hanging exactly over the beautiful prominence seen at its root. It seemed an extension or better, a sequence of the solar eruption. However, the second group of prominences (at the S. W. limb) did not disturb, apparently, the coronal filaments.

The N. W. ray was one of the longest, about one and an half lunar diameter (from the limb). Curiously enough, its northern boundary was very sharp, even on the lunar limb. Therefore a dark rift was cutting the inner corona, seen even with the naked eye.

The southern streamers went so far as two diameters (from the limb). There the corona displayed its greatest activity. These streamers were complex, apparently double, as formed by two ogival overhangings.

On the whole, the corona was decidedly brighter than in 1900. Its tolerably regular features, its stellar form, the solar activity, were just things to be expected in a typical maximum year. At first glance, I was struck by the perfect likeness of the actual corona with the predicted drawings of the astronomical text books.

The General Aspects. The general appearance of the eclipse was perhaps less interesting than that of 1900. At totality, light was surprisingly intense. I did not find any difficulty in sketching, or reading fine print. The features of the landscape, the details of a railway engine, the divisions of a watch, all were seen very easily. The eclipse of 1900 is recorded a bright one; for myself, I believe that of 1905 yet brighter, a relation perhaps with the greater activity of the solar envelopes. Owing to the general illumination, decidedly lighter than a full moon night, I was unable to see any star or planet, with only the exception of Venus. The sky was gray, not dark, rather a neutral tint, especially in the north, with a yellow fringe in the south. Clouds were also grayish, but without unusual appearance. On landscape, everything was of the same grayish hue. One could but think of a rain of ashes or of a shroud and the prevailing impression was one of gloom and sorrow.

The eclipse wind was very noticeable, coming to a perfect calm some minutes after totality. In the shade, the fall of the temperature was about 5° F. In the heights of the atmosphere, the fall must have been greater, for at totality, a thin vaporous veil (alluded to before) sprang around the Sun. It was not a cloud, there being no motion, and unseen before and after totality, but rather a sudden condensation of the aqueous vapor by the coolness of the coming shadow.

3 Rue Achille-Bégé, Montepellier (Hérault) France.

Brilliant Meteor.—Jnst as I was in the act of making a micrometer bisection of Groombridge 3829 for a latitude observation tonight, a meteor dashed through the field of view, lighting the entire field with such a startlingly brilliant, *blue* light that I sprang from the eye piece with the instant thought that the tube was a cannon and that it had exploded. I recovered from the surprise in time to see the fireball, apparently nearly as large as the full moon and a very dazzling, brilliant (though blue) light, speed towards the pole. It vanished about midway between α and δ Ursae Minoris. It did not burst, nor did it leave a perceptible trail, but moved swiftly, and vanished as suddenly as it had appeared with almost no tapering off of size or brightness.

It moved slowly through 40° in six seconds,—and a very close estimate being made by the distance the star moved in the telescope while I was watching the meteor.

I would judge that it entered the atmosphere very closely in the direction of the line from this Observatory to Groombridge 3829 as the surroundings were lit up at practically the same instant that it appeared in the telescope. In addition to its size, and brightness, and blueness, the most striking feature was its sudden extinction after being at virtually maximum brightness throughout the entire arc of 40° although it was somewhat wider at about the middle of its observed sweep.

HERMAN S. DAVIS.

International Latitude Observatory,
Gaithersburg, Maryland. Oct. 1, 1905.

The Spectroheliograph of the Modern Observatory. The astronomical instrument named by the long word spectroheliograph is coming to

have a prominent place in the study of solar physics. It is based on the principle first applied by Hale and Deslandres almost simultaneously. It is easily understood by any one acquainted with a common spectroscope. Such an instrument has what is called a view telescope and another telescope called a collimator, which by the aid of a plane mirror in the optical train renders the two telescopes parallel to each other. Now if the eyepiece of the view telescope is replaced by a slit, then any portion of the spectrum may be chosen at will for study.

Let the image of Sun fall on the slit of the collimator, the light passing through the slit in the view telescope will give a spectrum corresponding to a part of its width. The adjustment of the slit last named may be so made as to allow only one line of the spectrum to fall upon it, the image so formed is that part of the Sun that is passing between the jaws of the slit at that instant. Now, if motion is given to the slit of the collimator so as to cause it to move over the whole disk of the Sun, a picture of the whole Sun in this one kind light can be quickly made. At this point inventors of this new instrument have had trouble. To secure the proper motion of the slit so as to make a proper exposure on all parts of the Sun for a single picture by a proper motion of the spectroscope, or by a motion of the telescope, which would amount to the same thing, is found to be no easy task, if delicate and refined results are undertaken. But the problem has been solved both ways, and a very good description of the spectroheliograph in its different forms, as now used by astronomers will be found in the March number of *Monthly Notices*, (English) for 1905. The article referred to is by William J. S. Lockyer.

New Theory of Evolution of the Solar System.—In the San José *Daily Mercury* Sept. 1, 1905 occurs a very readable article by M. D. Gage, concerning the mathematical relations of the distances of the various planets from the center of the Sun, with reasons for their variations. The existence and places of Vulcan and Eros are also considered.

From the author's view of the distance of Vulcan from the Sun's center he is quite sure, that this object, if it exists, will never be seen in a total eclipse of the Sun because too near to the solar surface, being hidden by the Corona.

The assumptions that the author makes in regard to this and the important part that oxygen plays in these fundamental numerical relations that have been derived primarily from celestial mechanics are a little too broad to be safe in our present knowledge of fact. The reading of Mr. Gage's article will interest the practical astronomer of to-day in several kindred lines of interesting research.

Elements of Descriptive Geometry by Charles E. Ferris, Professor of Mechanical Engineering, University of Tennessee is a new work published by the American Book Company. The new feature noticeable in this work is that to which the author calls attention in the preface. Nearly all the work of the draftsman is now done in the third quadrant or angle. He adapts his text to this common practical experience, believing, as he says, that the student may learn to think just as well "behind the vertical and perpendicular planes, as in front of those planes."

The text contains nine chapters covering 127 pages. The themes discussed are problems on the point, line and plane, single curved surfaces, double curved surfaces, intersection of single and double curved surfaces by planes and the development of surfaces, intersection of solids, warped surfaces, shades and

shadows and perspective. Its illustrative problems are typical and appear to be well chosen for the purpose. We notice that to show projections on the horizontal and on the vertical planes the author uses r and h as exponents instead of the ordinary indices. The work is so easily graded, that it could be used successfully by the average student, ready for such work, who might wish to take a course by himself in this line of study.

U. S. Naval Observatory Eclipse Expedition.

Shortly before the departure of the eclipse expeditions Superintendent Chester of the Naval Observatory issued a comprehensive circular with reference to the path of the shadow of the Moon, the comparative accessibility of the different parts of the path, and another of the plans of the Naval Observatory officers for observation, together with a statement of the more important elements of the equipment of each of the three parties going from that observatory.

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The points to which astronomers, attention was especially called, were:

"(*a*) *The relative position of the Sun and Moon at the time of the eclipse.*—The angular distances between the centers of the Sun and Moon may be derived from observations of the four contacts by visual or by photographic methods. This necessitates an accurate determination of the latitude and longitude of each observing station, which necessarily consumes a large amount of time and labor and demands the use of a special instrumental outfit.

Since the position of the Moon is so well cared for by meridian observations and since the additional data derived from contact observations is small in quantity and of a distinctly lower grade in quality, it follows that contact observations should be considered of secondary importance compared with the work in other lines.

(*b*) *The search for intramercurial planets.*—Hitherto photographic searches for intramercurial planets have been made with incomplete apparatus or have been interferred with seriously by clouds.

In this eclipse it is highly important that a photographic search be prosecuted at two or three widely separated stations with very complete apparatus.

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The work of the corona should be considered of the highest importance.

(*d*) *Spectrum Work.*—All the facilities available to the astronomy of the present day for photographing the spectrum of the reversing layer, the chromosphere, the prominences, and the corona, should be used to their utmost capacity in the coming eclipse. On account of lack of light the slit spectroscopes used wil

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be confined to a few special problems, leaving the great bulk of the work to be executed by objective spectrographs using either gratings or large prisms.

It is also suggested that a number of spectrographs be employed to determine the accurate wave-length of the principal coronal line.

The spectrum work should be considered of equal importance with that on the corona.

(*e*) *Photometry; shadow bands.*—Of secondary importance are photometric observations and observations of the character of the so-called shadow bands.

(*f*) *Polariscopic work.*— Polariscopic and polarigraphic work should be well cared for with increased facilities for accurate work. Polariscopic work should be considered of importance nearly equal to that on the corona and the spectrum

(*g*) *Meteorology.*—The meteorological conditions existing at the several stations especially during the progress of the eclipse should be observed by means of the best self-recording instruments. This should be considered the most important of the secondary work."

The more important elements of equipment prepared for the three observing stations of the Naval Observatory were:

"1. A station near the central line, possibly on one of the islands of the Columbretes group off the east coast of Spain.

A horizontal photographic telescope, 5 inches aperture and 40 feet focus.

A photographic telescope, 8.5 inches aperture and 12 feet focus.

A 6-inch Dallmeyer camera, 36 inches focus.

A portable telescope for contact observations.

Several grating spectroscopes.

Spectral photometric apparatus.

Meteorological apparatus.

2. A station 10 to 15 miles within the edge of the shadow path, probably near Valencia.

A horizontal photographic telescope, 7.5 inches aperture and 65 feet focus.

A prismatic spectrograph.

A photographic telescope, 9.6 inches aperture and 14 feet focus, with color screen.

A 6-inch Dallmeyer camera, 40 inches focus.

A portable telescope for observing contacts.

A concave grating spectrograph.

Meteorological apparatus.

3. A station near the central line, probably near the line of the railroad from Tunis to Algeria in Africa.

A horizontal photographic telescope, 5 inches aperture and 40 feet focus.

A photographic telescope, 7 inches aperture and 114 inches focus.

A 6-inch Dallmeyer Camera, 40 inches focus.

A portable telescope for observing contacts.

A concave grating spectrograph.

A chronospectrograph.

Polariscopic apparatus.

Meteorological apparatus.

Each station will be supplied with instruments for the determination of time. Where telegraphic facilities are available the stations will be supplied with chronographs and portable transits for the determination of longitude."

San Miguel Mountain as a Site for an Observatory. Some time ago Dr. John D. Parker of New Haven wrote us concerning Mount San Miguel as a site for a large astronomical observatory. While living in San Diego, he organized a party and ascended the mountain for the purpose of learning what he could about the top of the mountain as a suitable place for astronomical observation. While Dr. Parker is an enthusiastic amateur of considerable ability, he does not offer his views of this site as those of a professional expert, but he does wish to express a deep interest in the advancement of astronomy by calling attention to another site for an Observatory in California that ought to be thoroughly inspected and used if suited to the purpose.

Dr. Parker's description is as follows:

1. San Miguel is a sugar-loaf mountain of the Coast Range of mountains about sixteen miles east of San Diego, California.

2. San Miguel is about 3100 feet in height. The view from the summit is one of the finest in Southern California. San Diego County lies like a checker-board at the feet of the observer.

3. The mountain posesses an unbroken horizon on all sides.

4. There are no gulches on the sides of the mountain in whicn hot vapor accumulates to rise at night to obstruct observation.

5. The warm current from the Japan Sea, and the cold current from the North, which unite along the Pacific coast to generate fog, decrease in force as producers of fog, as we proceed southward, and are less at San Diego, California, than at any other point further north. In the year 1894, nine fogs were noted by the Weather Bureau at San Diego, fourteen on San Diego Bay, and forty-three at Los Angeles. The summit of San Miguel is lifted almost entirely above all fog.

6. The land breeze, which blows at the average rate of two miles an hour, at San Diego, will clear the atmosphere from all dust or smoke, at night (when observations generally are taken,) which arise from San Diego, even if the city becomes large. The climate of Southern California is almost perfect, and the nights are so warm and delightful that observations at night during all seasons of the year can be conducted without inconvenience.

7. There is very little cloud in Southern California, to intercept observations at any time of the year. There are about 300 nights in each year, when observation could be carried on, without interference of the clouds, while in many places where observatories have been located, about half of the nights of the year, the telescope cannot be used on account of the clouds.

8. San Miguel lies in the thirty-second parallel of latitude, so the horizon would include nearly all the Southern Constellations, which are not so well known to astronomers as the Northern Constellations.

9. The summit of San Miguel is composed of Phonolite, a species of Porphyry, an excellent building stone for the observatory.

10. The summit of San Miguel consists of two distinct peaks, about a quarter of a mile apart. The Celestial Observatory could be built on the Western Peak, which is a little the highest, and the Terrestrial Observatory could be built on the Eastern Peak.

11. The observatory work should be dual in character, both observatories being under one management.

The Earth Floats in Water. The most singular and nonsensical theory of the Earth flatteners as they are called is one that comes from a man of unusual

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